POWER PLANT ENGINEERING

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Kewanee Water Works

THIS PLANT SUPPLIES THE CITY OF KEWANEE, ILL., WITH 450,000 GAL. OF DEEP WELL WATER PER DAY

IN ORDER TO BE ABLE to supply adequately the increasing demands of the city, for water, Kewanee, Ill., has been compelled to enlarge its facilities for handling this commodity, and accordingly, under the direction of C. A. Chapman, Inc., consulting engineers of Chicago, the plant was recently redesigned for increased capacity. This plant obtains its water from deep wells by means of an air lift. The changes deemed necessary, consisted primarily in sinking a new and deeper well, in building a new reservoir, in replacing the air compressor by a larger unit, in putting in an additional pump of greater capacity and in installing the necessary additional boiler capacity.

The present station supplies the city with approximately 450,000 gal. of deep well water per day. The plant comprises two distinct systems, one the air system by means of which the water is brought to the surface, the other the pumping system which serves the city mains.

The new well, in which the water level is normally 256 ft. below grade, is 2497 ft. deep. Water is brought to the surface and discharged into a half million gallon reservoir through the agency of an air lift. Besides this well there are the two original wells, each of which is 1400 ft. deep. These wells are no longer maintained in active service, but they are fitted with an air line and are kept in working condition so that they are available for use in emergencies.

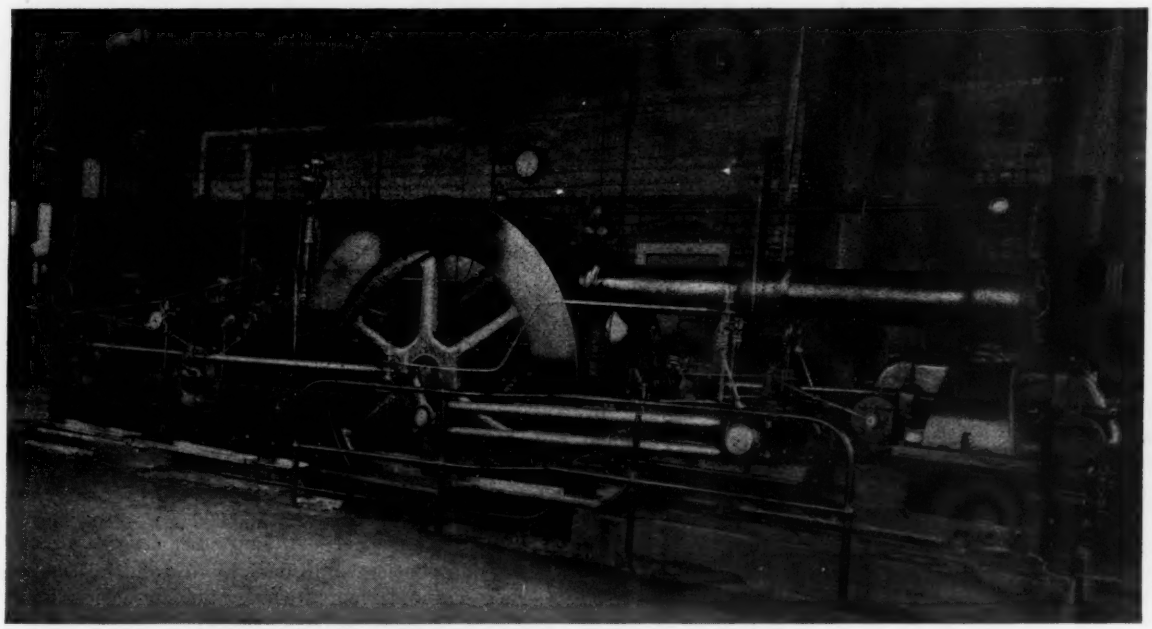


FIG. 1. SIDE VIEW OF THE TANDEM AIR COMPRESSOR AT THE KEWANEE WATER WORKS

The new well casing is placed in four sections, as illustrated in Fig. 2, the first of which is 18 in. in diameter and extends to a depth of 40 ft. Below this there is a 360-ft. length of 16-in. casing, and extending below this is a 14-in. section, 1050 ft. in length. The remaining section of the total depth resulting, of approximately 2500 ft., is a 12-in. incased hole in rock. A 3-in. air line about 600 ft. long extends down into the 14-in.

section. Air from this line at a pressure of 130 lb. lifts the water in a 6-in. pipe to a small splash tank about 18 ft. above the surface from which it flows by gravity through a 12-in. line to the reservoir.

The static level in this well is about 256 ft. below the surface. Under operating conditions, however, this level is lowered about 70 ft. so that the lift becomes about 325 ft. As the air is introduced at a depth of 600 ft., the head at that point is only 275 ft. The submergence percentage is then 45 per cent, while on starting it is 57 per cent. The volume of air required to start is less therefore, but on the other hand the pressure must be increased to a point only slightly under 150 lb.

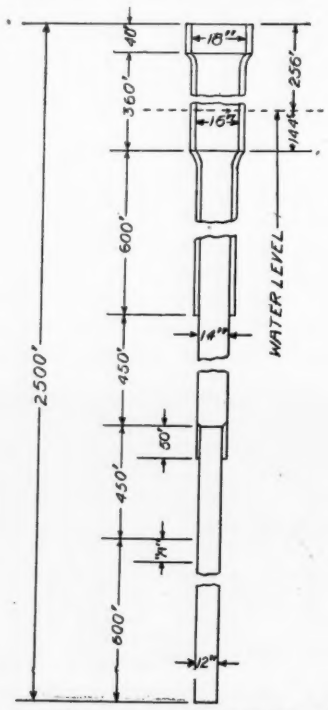


FIG. 2. SECTION OF THE DEEP WELL CASING

Located on the opposite side of the wells from the pump house is the reservoir. It is 72 ft. 6 in. long by 60 ft. wide by 17 ft. 3 in. deep and is constructed throughout of reinforced concrete. The total volume is about 75,000 cu. ft. and the capacity, allowing for piers and various irregularities, with 15 ft. of water is approximately 500,000 gal.

Although the reservoir is 17 ft. deep, it is not entirely below grade. It was thought best to place the reservoir partially above so as to reduce as much as possible the cost of excavation. A compromise was made between placing it entirely above ground and entirely below so that as it stands it is about half and half below and above this grade line. The top is floored over, covered with earth to a depth of several inches and sodded. A slope is built up to it from the surface level which is also sodded. The result is a kind of grassy knoll which has a pleasing effect on the observer. The floor over the reservoir is reinforced concrete 6 in. thick supported on girders 18 in. deep by 12 in. wide spaced on 12-ft. centers across the width of the structure and on 15-ft. centers along the length. These beams are supported on 16, 12-in. round columns. The bottom of the reservoir has a 0.5 per cent grade along both the length and breadth of the tank to a sump in the southwest corner, directly under one of the two pent houses which are located on the top of the reservoir on opposite corners. The one over the sump, which is nearest to the pump house, houses the controlling valves, and a depth gage which is readily visible, through a suitably located window, from the plant. These houses are open to the atmosphere through fine mesh screening, for the purpose of properly ventilating the water. To aid in accomplishing this result, one tower is built somewhat higher than the other so as to secure a chimney action and so insure a current of air over the surface of the water at all times. For normal operation, the water in this reservoir is kept at a depth of about 12 ft.

The construction of the tank is such that if, at any future time, it becomes necessary again to increase the capacity of the station, the reservoir capacity may be added to by simply building another section adjacent to the present one, on the north side.

Compression System

Air is supplied to the well at 130 lb. pressure and at the rate of about 1200 cu. ft. per minute, measured at

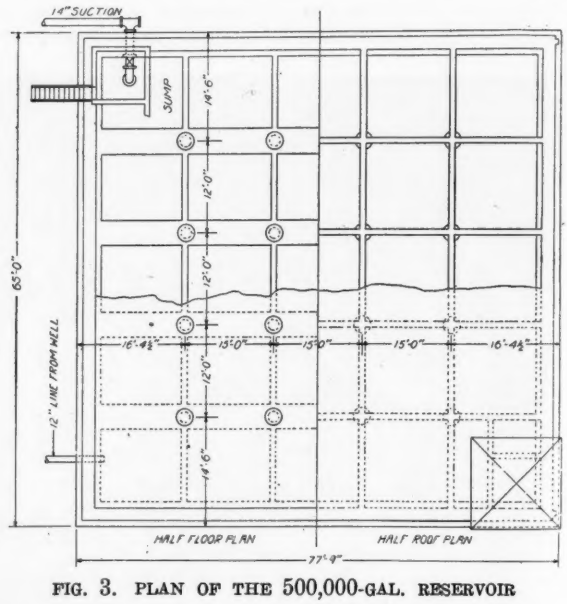


FIG. 3. PLAN OF THE 500,000-GAL. RESERVOIR

free atmospheric conditions, by a tandem compound Corliss engine driven, two-stage tandem compressor, the side view of which is shown in Fig. 1. Air is conducted to the low-pressure cylinder of this machine through an 18-in. duct from the roof. In this cylinder, the pressure is raised to 30 lb. and a temperature of about 250 deg.

A great portion of the heat thus generated is removed in the intercooler. The high-pressure cylinder takes the cooled air at 30 lb. and compresses it to 130 lb. at a temperature of 265 deg., under which conditions it is conveyed to an air tank through a 6-in. line. This tank has a diameter of 4 ft., is 10 ft. high and has a capacity of about 125 cu. ft. A 6-in. line from this tank conducts the air through a reduction fitting to a 3-in. line which

is carried out to the well. All air lines as well as the tank are bare to allow for additional after cooling.

Cooling water for the intercooler is taken from and delivered back to the main service lines. The air inlet valves on both high and low-pressure cylinders are of the semi-rotary, Corliss type, mechanically operated by an eccentric on the flywheel shaft. The discharge valves on both cylinders are of the poppet type and are automatic in their action. The high-pressure cylinder has a diameter of 14½ in. while that of the low is 24 in. The stroke is also 24 in. A piston rod, built up in several sections connects all four pistons and is so designed that the clearance of any one piston may be adjusted separately.

The power end of this machine consists of the regular Corliss engine. Steam is admitted to the high-pressure cylinder at about 140 lb. pressure and expanded down to a receiver pressure of 20 lb. The low-pressure cylinder exhausts through a 10-in. exhaust header into an open feed-water heater. The diameter of the high-pressure cylinder is 16 in. and that of the low is 28 in. The stroke is, of course, the same as that at the compressor end, 24 in. The receiver consists simply of a short length of well insulated 8-in. conduit beneath the frame.

Between the steam and air ends of the compressor is mounted a double flywheel on a crankshaft, the center line of which is above that of the piston rod by an amount sufficient to provide ample clearance between the shaft and rod. Connecting rods are connected to cranks on the outside of the flywheels and are actuated by a crosshead between the high and low-pressure air cylinders, so that, from the standpoint of the steam end, the engine is back-acting.

The result of this double tandem arrangement is to make an extremely long and narrow unit that is particularly well adapted for the available space, as will be noted by reference to the plan of the station, Fig. 4.

This compressor is rated at 1500 cu. ft. capacity, running at 120 r.p.m. and under a pressure of 100 lb. develops about 210 hp. which, with a water rate of about 22½ lb. would require boiler capacity to the extent of approximately 270 hp. This machine is set to carry a pressure of 130 lb. and ordinarily runs at less than 100 r.p.m.

Speed regulation is effected by a speed and pressure governor. When the speed of the compressor reaches a point at which the air supply exceeds the demand, the speed element slows the machine down; when the air pressure exceeds the point at which the pressure element is set to act, 130 lb., this apparatus also operates to reduce the speed.

Under normal operation the machine is capable of delivering about 850 gal. of water per minute to the reservoir, and as the daily demand is approximately 450,000 gal., it is necessary to run the compressor for only 9 or 10 hr. per day.

Pumping System

The city mains are served by a duplex piston pump driven by and direct connected to a cross-compound Corliss engine, as shown in Fig 4. This pump takes water from the reservoir through a 14-in. suction line at a head of a few feet and delivers it at a pressure of 35 lb. per sq. in. through a 10-in. discharge to the city mains. The plungers, which are fitted with outside center packing, are 8¾ in. diameter and have a 14-in. stroke, so that, operating at 65 r.p.m., which corresponds to the normal demand, it is capable of delivering about 900 gal. per minute. The speed ordinarily ranges between 35 and 75 r.p.m., being lowest, of course, at night. Although the pump maintains a pressure of 35 lb. it was designed to carry 65 lb. with an allowable emergency fire pressure of 100 lb. per sq. in.

Power is supplied by a 10 by 20 by 14-in. cross-compound engine. The plunger rods form a continuation of the piston rods; the flywheel is on the opposite end of the steam cylinders. The high-pressure cylinder of this engine takes steam throttled to 85 lb. pressure and exhausts to a receiver pressure of 5 lb. The low-pressure cylinder exhausts into a 25-in. vacuum.

Regulation is accomplished by a governor operated by water pressure which accurately maintains pressure at 35 lb.

Vacuum is maintained by a surface condenser having an area of 125 sq. ft. which is installed in the suction line to the pump. A 10 by 7-in. air pump, directly connected to the crankshaft of the pump engine handles the air from the condenser.

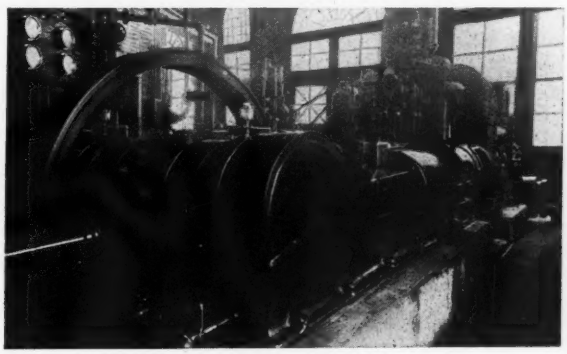


FIG. 4. CROSS-COMPOUND ENGINE-DRIVEN DUPLEX SERVICE PUMP

If at any time the demand exceeds the amount which this pump is capable of supplying, an emergency pump which was retained from the old installation is at hand and ready at all times to be pressed into service. This arrangement insures continuity of service and allows the larger pump to be shut down, during periods of light loads, for overhauling.

The plant, in accord with modern practice, is not equipped with a standpipe. Pressure regulation is accurate without it and it is thought that the pumping units are sufficiently reliable to obviate the necessity of storage capacity, under pressure.

Boiler Room

Steam is generated for the two power units in three 200-hp. boilers, which are operated, for full load conditions, at about rating. These boilers, of the standard return tubular type made by a local manufacturer, use the local coals. Run-of-mine coal from mines in the vicinity of Kewanee is the grade generally employed.

The fuel is not of particularly high grade and some trouble is experienced in keeping the stack clear with

the hand-fired settings with which the boilers are equipped.

Well water is employed for boiler feed, but in its raw state is unsuited for the purpose. On this account a water softening plant is used to reduce the hardness. The softening process is of the lime and soda ash variety working on cold water. A housing for the settling tank and the necessary pumps is located just outside the boiler room, to the north. The water obtained at this station was particularly hard at the outset when the new well was first pumped, but it has gradually been getting softer, except during a few periods when a relapse has set in. Analyses of this water have been made from time to time, at the University of Illinois, but by the time the results were known it has been too late to alter the treatment to correspond. For this reason, the treatment has not been entirely satisfactory. It is to be supposed, however, that, as conditions adjust themselves to a more or less constant state, the treatment will more nearly fit the ill.

Before being fed to the boilers, the water is heated in an open feed-water heater, by the exhaust from the compressor and feed pumps, to a temperature of approximately 200 deg. The feed pumps, located in the compressor room so as to be under the immediate supervision of the engineer, are installed in duplicate for safety, one being sufficient to handle the feed to the boiler at rated capacity.

Steam is generated at 150 lb. pressure and is taken off through a 5-in. header into an 8-in. main from which it is distributed to the compressor, in a 6-in. line, to the pump through a 4-in. line, and to the feed pumps. Separators are placed in the lines to the compressor and pump to insure dry steam for these units.

IN A BUILDING under construction in Cleveland, Ohio, considerable concrete work was put in through an architect's error. It was found necessary to remove the misplaced structure, and a crew of laborers assigned to the task attacked the concrete with sledges and drills. At the end of three days, the progress made was so small that other and more rapid means of removal became imperative.

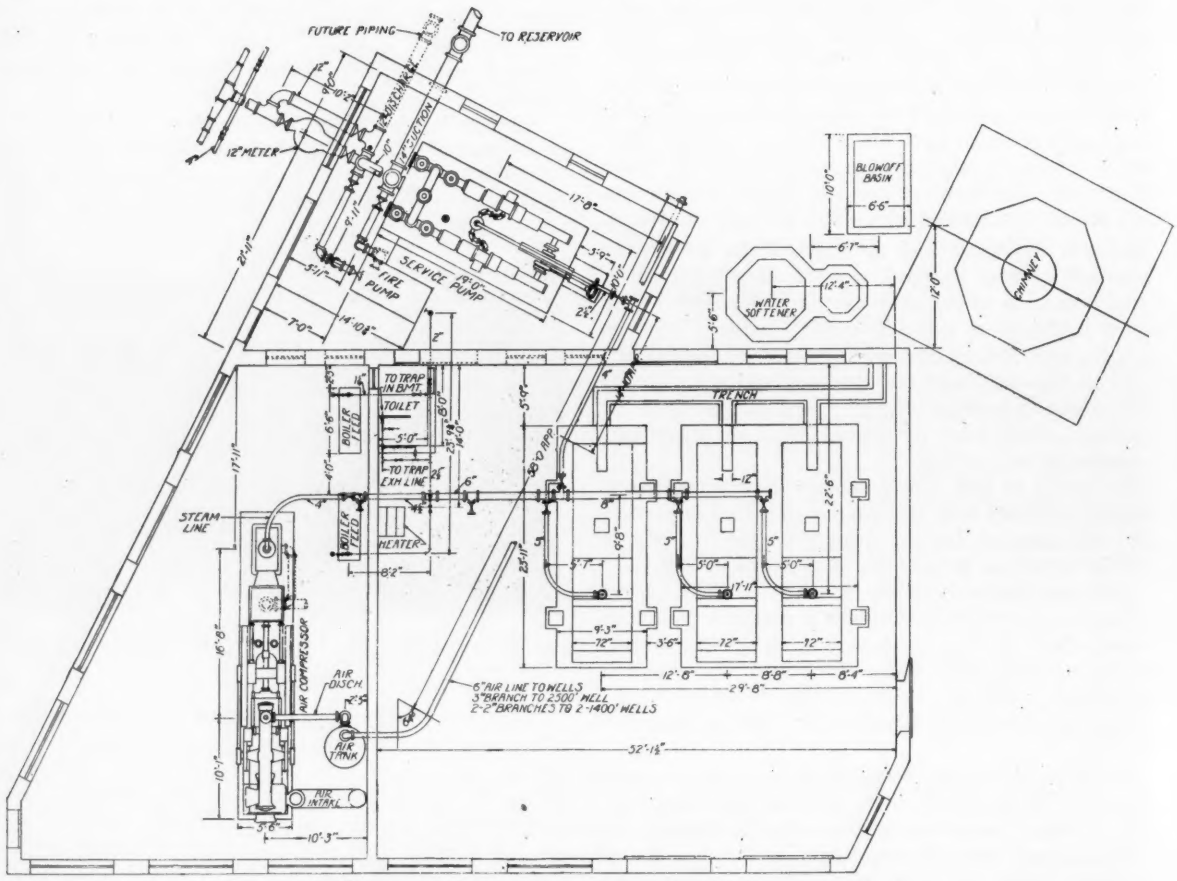


FIG. 5. GENERAL PLAN OF THE KEWANEE WATER WORKS

In the emergency, a practical gas welder was called in to determine what could be done with the oxy-acetylene torch. A demonstration proved the feasibility of speeding up the work with the torch and the job was thereafter turned over to a local welding firm.

The method employed consisted of heating along the line of the desired fracture with an ordinary welding torch, using a long bushy flame. The concrete was not raised to a great heat, as measured in terms of oxy-acetylene, but the heat was confined as much as possible along the proposed line of fracture. When so heated, the concrete yielded to a heavy blow of the sledge, breaking off in the predetermined form and bulk.

Zero Water for Boiler Feed

DISCUSSING A METHOD FOR OBTAINING WATER OF ZERO HARDNESS AND ILLUSTRATING THE ADVANTAGES TO BE DERIVED BY ITS USE. BY LEROY W. ALLISON

WATER AND WATER supply form the basis of all steam power plant operation, regardless of the character of the station, nature of the fuel, or the particular function of the plant. Many a boiler room problem is solved by an analysis and subsequent conditioning of the feed water, and many a dollar is saved when this root of trouble is corrected.

Thus, the efficient treatment of water for boiler feed purposes is one of the first steps for real power plant efficiency and economy; without it, any station can get only just so far in point of desired operation. Many a chief engineer, plant superintendent or other station official can testify to the advantages attending proper attention to boiler feed water. Not only boiler room tests, but everyday operation show the startling contrasts and results to be secured in the use of what is commonly termed "soft water" as compared with "hard water."

by the steam engineer and become part of his daily text for correct station performance.

Much has been written on the subject of water softening by those who do know what they are talking about, and by those who think they know; the literature ranges from the highly specialized technical article, with calculations mystifying to the uninitiated, to the promotion literature of manufacturers of material for water treatment.

All this may have its place, but the happy mean between the two extremes is found in the portrayal of actual operation—a concrete explanation of just what is being accomplished in this line in different power plants. It is information of this sort that really counts, and it is information of just this sort that the accompanying brief article seeks to give; also, at the same time, to correct, if possible, the misleading references, frequently encountered in engineering literature and heard by word of mouth, on this essential subject.

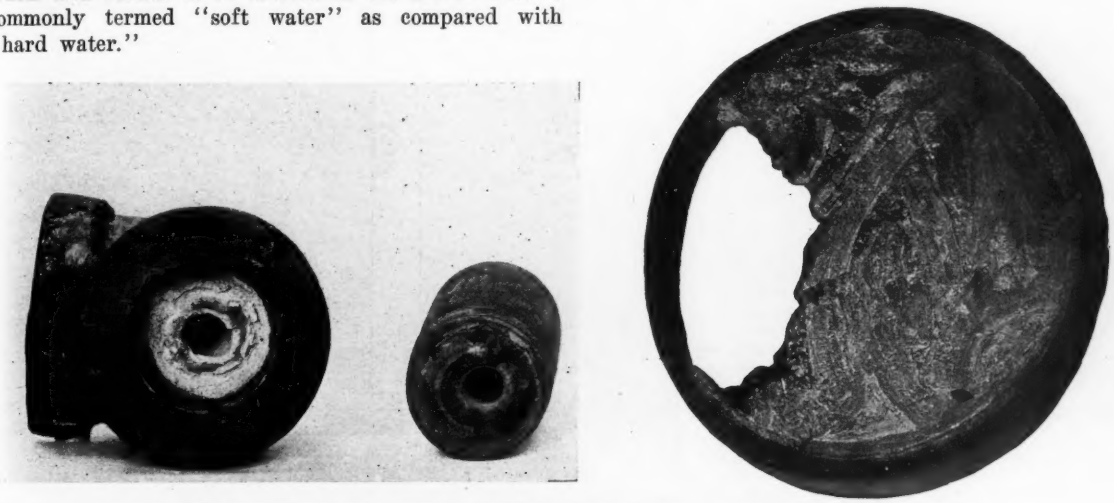


FIG. 1. TYPICAL CONDITIONS OF LIME AND MAGNESIA SCALE IN POWER PLANT PIPE LINES. NOTICE HOW THE SCALE HAS PRACTICALLY SEALED UP THE PIPES

In the final calculation, there is little or no basis of comparison between the two; for soft water has every element of service, economy and efficiency on its side, while hard water stands simply as the "easy way out" for the engineer who travels far behind the times or is too blind to see, or the plant that cares little as to how many dollars are wasted in interruptions, repairs and replacements. Engineers and plants of this caliber do exist today, strange as it may seem.

While an intimate knowledge of water and water treatment for boiler feed, as well as for other purposes, belongs properly to the field of the chemist, the broad development in power plant engineering makes imperative that certain fundamental facts and information on the subject be at the finger tips of the chief engineer and power plant official. The general impression that the matter is one of high technical scope is a mistake, and true only in the sense where chemical analyses and solution of special problems are involved. Practical work requires practical men, and we have come to the point in water rectification where a definite working knowledge of the fundamentals can be easily attained

ZERO WATER

THE ONE big end to be secured in water rectification for boiler feed, as well as for other service, is that of "zero water," or water of no hardness. Much of the literature previously referred to informs the reader that this is practically impossible, that "absolutely pure water cannot be obtained in everyday practice." This is not so, for it can be secured, as numerous power plants and other industrial works in active operation testify.

The engineer in charge of a power station prefers the word of the practical man, rather than that of the theorist, just as he looks to the functioning boiler plant installation and performance records for positive facts regarding efficiency in operation. When he is told by a fellow engineer that his boiler feed water is pure and soft, he is likely to believe it.

Water Impurities

Water impurities as commonly found are quite well known to the steam engineer, and a brief word on the subject will suffice. Rain-water is the only soft water to be found in nature, and this is not necessarily 0 deg., or zero hardness. All other natural waters contain different impurities in different degrees, caused by substances in solution or suspension. When water is converted into steam in the boiler, such impurities as exist are deposited somewhere in the boiler unit, while the gaseous substances pass off with the steam or are driven out by the feed-water heater.

Naturally, it is impurities to which the engineer directs attention for correction, for it is these that bring about different familiar boiler troubles. For such ailments there are numerous individual remedies, some effective, some otherwise; but the real solution of the difficulties, one of positive assurance, is found in a feed water supply of zero water.

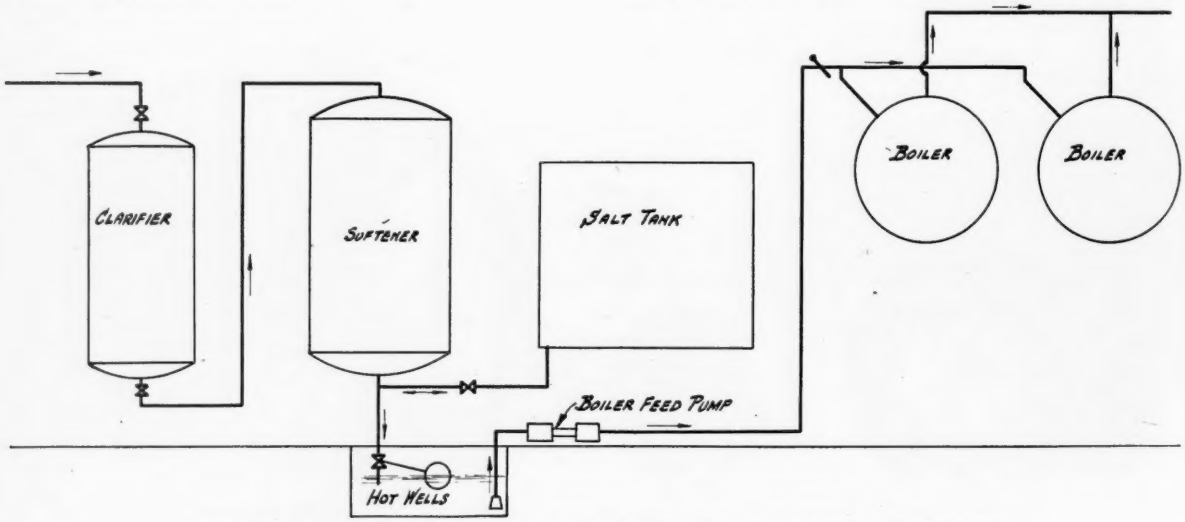


FIG. 2. ZEOLITE WATER SOFTENER INSTALLATION, SHOWING PIPING ARRANGEMENT

The presence of such substances in the water as chloride and sulphate of magnesium, dissolved carbonic acid and oxygen, grease and acid bring about corrosion; while incrustation, commonly known as "scale," is the result of such impurities in the water as calcium carbonate (lime), calcium sulphate, magnesium sulphate and magnesium carbonate, as well as substances found in smaller quantities as calcium chloride, magnesium chloride and bicarbonates of iron; also, sediment, such as mud and clay.

The internal corrosion of the boiler, the formation of scale in the feed lines and boiler tubes, the formation of scum, the precipitation of mud, and the like are responsible for plant interruptions and heavy operating expense. That these conditions can be avoided is an acknowledged fact, and is shown indisputably by the actual operating results secured in modern, progressive power stations where concerted and intelligent thought has been given to the matter of water rectification—the heart of the trouble.

Scale

As one of the most common and distressing troubles in power plant operation is found in the formation of scale in boiler tubes, feed-water lines and piping systems, this topic is worthy of particular emphasis.

The accompanying illustration, Fig. 1, shows three common instances of lime and magnesia scale deposits in power station pipe-lines. The loss in efficiency and increased demands made upon operating equipment in water circulation through pipes of such reduced diameters can be measured directly in dollars and cents, and over a period of time will show enormous waste.

The specimens illustrated might be considered by some as "exaggerated instances" of scale formation, but they are not, being simply typical examples of pipe-line conditions in the power plant which is giving little or no thought to the subject of water rectification, or utilizing unfit materials now on the market intended for the purpose of correcting such evils, but in reality intensifying the trouble.

As the experienced and well-informed steam engineer knows, scale does not exist where water of zero character is used. This is a positive statement, and is so intended to be; it is not based upon theory, but upon the actual assertions of engineers and power plant officials at stations employing treated water of the nature mentioned.

Zeolite Water-Softening System

The term "zeolite" is a common one where water treatment is mentioned. This is a material which possesses the unique ability of exchanging sodium for calcium and magnesium in the water-softening process.

The material is used in the form of a bed in a softening tank or container; as the hard water is passed through this bed, the exchange takes place instantly, the zeolite retaining and absorbing all the hardness and forming, instead, harmless sodium salts. The action is one of automatic chemical exchange, and not a reaction between the materials.

The zeolite bed can be used again and again for an indefinite period of years. The action, or work of the material does not deteriorate its ability to function as often as required. The zeolite is regenerated or brought back to its original state by using a solution of common salt dissolved in water; this solution is passed through

the bed in a direction opposite to that of the hard water, and a reverse of the softening exchange takes place; the calcium and magnesium absorbed from the hard water are replaced by sodium, and the destructive minerals are discharged to the sewer as a clear solution.

A typical installation is set forth in the line illustration, Fig. 2, and the apparatus required is as simple for ordinary work as is the action of the material in making perfectly soft, or zero water. As will be seen, the water enters a filter for the purpose of preliminary cleansing, and then passes to the softener. After passing through the bed of zeolite, it flows into the hot wells, or heater, thence to the boiler feed pumps and so on to the boiler.

A salt tank is installed, as will be noted, for regenerating the material, with valve control on the line leading to the softener. When the desired output is reached, as indicated by the meter, the valve controlling the line from the softener to the hot wells is closed, and that valve between the salt tank and softener opened, allowing the salt solution to act upon the zeolite bed.

This process is repeated from day to day. The installation can be made in the exact size required for the particular plant, giving full reliable 24-hr. service where such demand exists.

The size of the equipment, as will be understood, is dependent upon the capacity and demands of the plant, as well as upon the character of the water to be treated. Where, say, hardness of five grains exists in water, and a certain number of thousand gallons is required in a specified period of hours, the installation would not be the same as where seven grains of hardness were shown and a greater volume of soft water needed in the same period of time. Two water softeners frequently will be found operated in unison, to provide an uninterrupted flow of soft water throughout 24 hr. continuous operation from day to day.

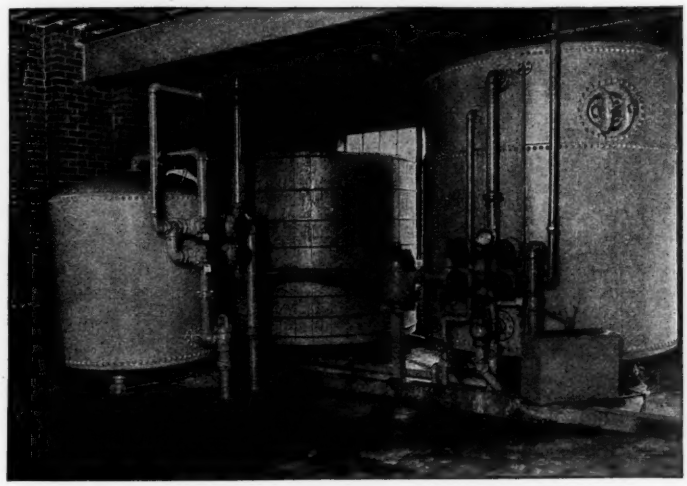


FIG. 3. PHOTOGRAPH OF WATER SOFTENER INSTALLATION SHOWING SOFTENER, CLARIFIER AND SALT TANK

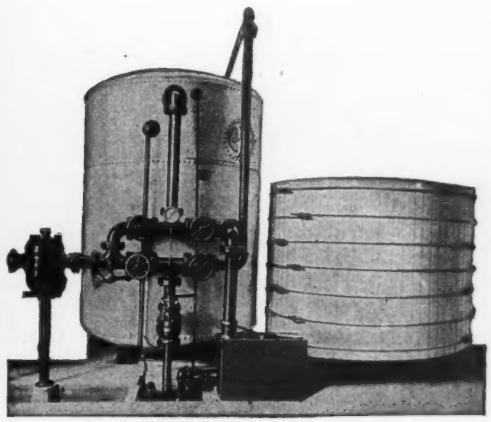


FIG. 4. VIEW OF SOFTENER AND SALT TANK

Zero Water in Service

In the water-softening process as just described, the water, following treatment, is not only of zero hardness but is absolutely clear and free from suspended matter or sludge and mud-forming impurities, and no accumulation of these harmful materials can possibly occur under correct operation.

As has been stated, the zeolite method of softening water is simply an exchange of sodium (Na) salts for injurious calcium and magnesium salts, and since these materials, known in chemistry as "Na salts," are all highly soluble in water, no precipitates or scale forming impurities remain after the action.

This last statement should be noted carefully, as reference frequently is seen along the lines of "there is always some precipitate in the boiler," etc. This is not true where water of true zero hardness is delivered.

Another common statement open to correction is that often made with regard to sodium salts in boiler water resulting in foaming and priming. There is no justification, or logical basis for such an assertion. The concentration of sodium salts (as with any other salts) in boiler water necessary to cause trouble of this character is high, and such concentration can be held within allowable limits by judicious blowing down; consequently, there is no excuse for foaming, and none need occur.

Boilers and auxiliary operating apparatus are maintained clean, permanently and positively, by the use of water so treated. Moreover, with the prevention of scale formation and deposits on the interior surfaces and parts of boilers, leaks, near-leaks and failures become visible instantly under ordinary inspection, as there are no solid substances in the water to plug up and hide small holes. Such a condition goes far to eliminate numerous shut-downs and interruptions, as well as danger from explosions. The small, though dangerous leaks, can be discovered and easily repaired before any harm ensues.

The value and economies effected by removing undesirable impurities from boiler feed water before it enters the boiler, cannot be over-estimated. The steam engineer is thoroughly familiar with the hardships and expenses occurring through a neglect of this important phase of plant operation—the tube replacements necessary and

boilers idle in the meantime; cleaning, repairs and consequent labor costs; clogged up pipe-lines, condensers, hot-water pumps and the like, with scale-choked valves and leaky connections.

The expense of a water-softening installation is not to be compared with the results secured, and yet, if such were the case, it would be found that the savings and economies brought about return dividends sufficient to defray the entire invested capital within a brief period of time, at the most, in 24 to 36 mo. This is not a mere generality statement, but based upon the actual experience of those who have made installations of this character.

It has been the writer's privilege to inspect performance statements covering a number of installations of zeolite systems for boiler feed water service, and a summary of these not only shows a remarkable degree of attainment, but indicates, in positive fashion, the absolute elimination of common boiler troubles through the use of zero water, and the pronounced advantages attending.

American Machinery Turning Wheels of the World

By B. K. Rhoads

IF THERE is one way in which America excels every other country it is in the invention, manufacture and use of machinery. In lighting and transportation in the cities and on the railroads, in the machinery that eases the task of the farmer, in every industry where it is possible to supplant human labor with the product of human ingenuity, the United States is developed far in advance of the rest of the world. It is natural that less advanced countries should look to America for the machinery that they are rapidly learning is essential for the proper development of their industries.

At the present time, there is an especially great need for machinery throughout the world. In Europe, there are vast power plants, factories and other industries which must have American machinery to enable them to start turning the wheels that were stopped by war. Many of these are entirely dismantled and must be entirely rebuilt. In South America and Asia, too, an increasing production activity is demanding improved methods which can only be accomplished by the installation of American machinery. All this would seem to indicate a lively demand from abroad for machinery of all sorts that is produced in the United States.

That this expected demand is not developing to any great extent is due to two causes. One is the lack of ready money among foreign purchasers and, coupled with this, is the unfavorable exchange that they must face in buying American goods. The other is the lack of adequate credit facilities in this country for financing the sale abroad of American products.

Take the case of a certain company in Brazil that now wishes to purchase a complete outfit of power plant machinery from a firm in the United States. The Brazilian company has not the ready money to pay for it, nor can it handle the purchase on the short-term credit basis to which Americans are accustomed to doing business, but must have the time to get the machinery and have it installed and actually doing work for it before it is called upon to pay for it.

Conditions that have thus brought American industry face to face with the difficult problem of maintaining trade relations with the rest of the world have not developed suddenly. The men who are active in the organization of the Foreign Trade Financing Corporation, for instance, have called attention to resolutions adopted by the American Bankers Association in 1918, even before the signing of the Armistice. At that time, the Association took this pledge:

"To support by every means in its power the development of export trade, to encourage manufacturers to enter upon this field of distribution, and to provide as rapidly as possible adequate facilities for financing export operations sufficient to meet every reasonable demand that may arise."

At that same meeting the bankers appointed a Committee on Commerce and Marine to work out a practical plan for meeting just the problem confronting exporters today.

The bankers foresaw closed factories, the collapse of prices of American manufactured goods, a severe decline in the market value of our wheat, cotton and other farm products. The world's imperative needs, however, delayed for more than a year this inevitable stoppage of export flow. Credits, mostly on a short-term basis, were provided to finance the vast volume of goods sent out of the country in 1919; and throughout most of 1920 the flow was maintained. Within the last few months, however, the prophets have been amply justified.

Wheat, corn and livestock are well below the average level of prices of the last 10 yr. Cotton has tobogganed to a figure that, 2 yr. ago, seemed absurd to the optimistic grower. In the case of manufactures, there has been either a severe cut in market value or a radical reduction of output. It was manifestly impossible, when foreign demand fell off, to maintain production with high-priced labor on the scale of 1917 to 1919.

Out of two years of study, American bankers and business men brought certain concrete proposals. The first was for an amendment to the Federal Reserve Act permitting the organization of private corporations for providing long-term credit for foreign buyers. That was passed and became a law (the Edge Act) in December, 1919.

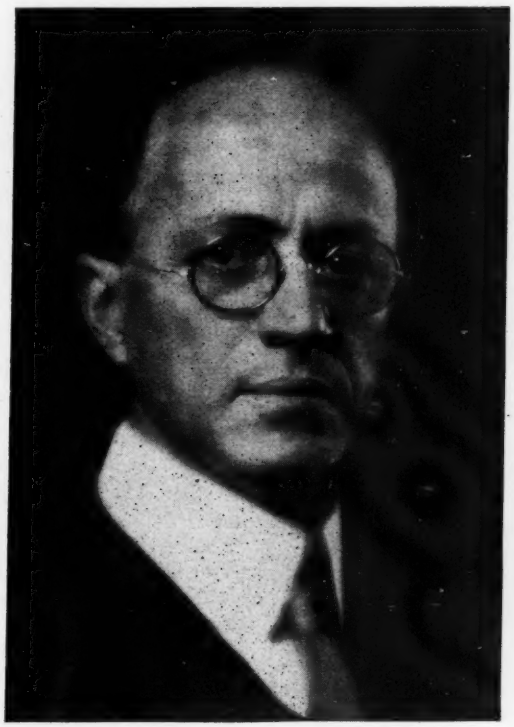
The next step, logically, was to organize under the Edge Act, corporations to subscribe capital and sell debentures (notes) to provide money for carrying sales on long credit terms. Under the law, they can use their subscribed capital and surplus for this purpose; and they are further permitted to sell to investors debentures to a total amount ten times their capital and surplus.

And now? It is up to the average American who can spare something from his earnings to turn these Edge Act Corporations into going concerns. That, at any rate, is the answer of the 33 representative American business men, agriculturists and bankers who are intent upon placing the capital stock of the Foreign Trade Financing Corporation in the hands of people all over the country. As they view it, the problem is one that can be solved only through co-operation by all.

COMFORT A. ADAMS

EDUCATOR, ORGANIZER AND ELECTRICAL ENGINEER. IS NOW CHAIRMAN OF DIVISION OF ENGINEERING, NATIONAL RESEARCH COUNCIL

THERE ARE, no doubt, many of us whose memories retain pleasant recollections of our childhood visits to the village blacksmith. It was at the open door of his forge that we lingered on our way home from school to admire the pyrotechnic displays that accompanied his art and where we beheld with childish amazement his feats of strength or his utter disregard for showers of sparks that leaped up from the forge as he worked the bellows. The forge was a never-ending place of interest where we as youngsters gathered in silent contemplation of the smith with "brawny arms." This picturesque character of days gone by is passing, however, and today, although the "spreading chestnut tree" may remain, we find instead of the smithy an automobile repair shop upon which are inscribed the words "Electric Welding Done Here."



C. A. Adams

The smith is no longer the authority on welding. Today the college professor and the research engineer disseminate welding lore and their workshops are the electrical and metallurgical laboratories rather than the smithy. It is the scientific man who, today, investigates the microscopic structure of metals and determines correct procedure and temperatures for welding by electricity or the oxyacetylene process.

Notable among engineers in this field is the subject of our sketch, Comfort Avery Adams, educator and electrical engineer. Known as an authority on electrical engineering and welding practice, he is at present chairman of the Division of Engineering of the National Research Council. Prof. Adams was the first president of the American Welding Society and is present director of the American Bureau of Welding.

Born in Cleveland, Ohio, the son of Comfort Avery and Katherine Emily Adams on Nov. 1, 1868, he received his early education in the Cleveland Public Schools. His father, who was then engaged in the wholesale clothing business, was a direct descendant of John Adams, who came from England to Plymouth Colony on the ship "Fortune" in 1621.

Endowed with a craving for scientific knowledge, the son, after leaving the public schools, entered the Case School of Applied Science from which he was graduated in 1890 with the degree of B. S. in electrical engineering.

Immediately upon graduating, Mr. Adams was confronted with an opportunity of joining a scientific expedition to Alaska, and being of an adventurous as well as scientific turn of mind, he accepted. The summer was accordingly spent in the vicinity of the Muir Glacier, where the party made the first survey of this river of ice and accurately measured its motion.

After a brief term with the Brown Hoisting and Conveying Machine Co., and as designing engineer for the Brush Electric Co., both of Cleveland, Mr. Adams went to Harvard in the fall of 1891 as an instructor in electrical engineering and as a student of mathematics and physics. Remaining at Harvard, he was made assistant professor of electrical engineering in 1896, professor in 1906 and since 1916 has been Lawrence professor of engineering. During the years 1915-1918, under the co-operative agreement between Harvard and the Massachusetts Institute of Technology, he was also made professor of the latter institution. After the dissolution of that agreement by the courts he was the first dean, during 1919, of the reorganized Harvard Engineering School, but resigned that post to accept his present position as chairman of the Division of Engineering of the National Research Council. He still retains his professorship at Harvard and gives a third of his time to his duties there.

In the spring of 1917 Professor Adams was appointed by President Wilson a member of the general

engineering committee of the advisory commission of the Council of National Defense, of which committee he was later made chairman. In this position he outlined a scheme, later adopted in part, for co-ordinating the purchase of war supplies by government departments. Under his direction, the committee also developed a cast steel anchor chain which was 40 per cent stronger than the standard wrought iron chain and could be manufactured at a reduced cost, involving a large saving in man power.

As chairman of a subcommitee on electric welding of the Emergency Fleet Corporation, he was instrumental in effecting notable advances in the art of welding, particularly in its application to ship building.

As an organizer and director of engineering and scientific bodies, Prof. Adams possesses exceptional abilities. He was largely responsible for the organization of the American Engineering Standards Committee, representing national and engineering societies and government bodies, which has now become the authoritative body through which the standardizing activities of all engineering, industrial and government organizations are co-ordinated. He was chairman of the organization committee as well as first chairman of the committee itself.

Aside from his activities in the educational field, Prof. Adams serves a number of large commercial organizations in a consulting capacity. He has been consulting electrical engineer for the American Tool and Machine Co. of Boston since 1900, the Warner Sugar Refining Co., New York, since 1910, the Okonite Co. since 1915, and the National Conduit and Cable Company since 1919. He has also acted at various times in a consulting capacity for the Stone & Webster Corporation, the Boston Edison Co., Public Service Co. of New Jersey, and others.

In 1894, he joined the American Institute of Electrical Engineers and has been active in its affairs ever since that time. He served as manager of the institute from 1912-1915, as vice president from 1915-1917 and was president during the year 1918-1919. He is a fellow of the American Academy of Arts and Sciences, and the American Association for the Advancement of Science and is a member of the following societies: American Engineering Council of the Federated Engineering Societies, Institution of Electrical Engineers (London), the Society for the Promotion of Engineering Education, American Physical Society, American Society of Mechanical Engineers, Society of Automotive Engineers, and the American Society for Testing Materials.

Prof. Adams is the author of numerous articles contributed to various technical journals and has made valuable contributions to the advance of the art of electrical machine design.

He was married June 21, 1894, to Elizabeth Challis, daughter of James Challis Parsons, a minister and teacher of Greenfield, Mass. They have two adopted children, John and Clayton Comfort Adams.

CLEANING UP a boiler room is a man's job. Keeping it clean is a bigger man's job. Increasing its efficiency is a still bigger man's job—and this leads directly to a still bigger job. Why not start?—Combustion.

Character of Iowa Coal

IOWA COAL is low-grade and noncoking bituminous, carrying considerable sulphur in the form of pyrite (FeE_2) and gypsum ($CaSO_4$). The gypsum coats the vertical faces of the coal so that it looks somewhat as though daubed with whitewash. In many places the coal is "bony." The change in character takes place in a short distance, clean coal changing to shale interleaved with thin layers of coal. In general, the coal is hard, slabby, or blocky, and makes a fair steam and domestic fuel, though sooty. The so-called Mystic or Centerville bed, which is mined longwall or semilongwall, makes particularly large coal blocks which are very much esteemed for domestic use in the country, as the coal can be stocked in piles and weathers more slowly. In general, Iowa coal weathers rapidly on exposure, hence does not store well, and if there is much slack present it soon takes fire spontaneously.

Iowa coals are used for locomotives, domestic purposes, and power houses. The coal tends to clinker in locomotive fire boxes and under boilers where there is a hot fire, though with care in keeping an even fire it is used successfully.

The Bureau of Mines has made few fusibility tests of the ash from Iowa coals, but it has tested many samples from the western part of the interior coal field in the adjoining states of Kansas and Missouri. These samples have invariably shown a very low softening temperature, ranging from 1850 deg. to 2100 deg. All of these coals contain considerable iron pyrite and partings of calcite and gypsum, which contribute the proper constituents for the formation of a fusible slag.

The order of fusibility of coal ash from the various coals of the country may be divided into three groups,

Class 1. Refractory ashes, softening above 2600 deg. F.

Class 2. Ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3. Easily fusible ashes, softening at a temperature below 2200 deg. F.

The coals from the western part of the interior field, comprising the states of Missouri, Kansas, and Iowa, are all in the lower part of Class 3; in fact, so far as known, they have the most fusible ash of all American coals.

Iowa coal cakes in a fire. In a retort it forms friable, porous coke, but it is not in any sense a coking coal. It does not coke in a beehive oven. In a retort oven or in a gas retort it makes a friable, porous coke which contains too much ash and sulphur to be valuable as a metallurgical coke; nor is the outlook promising for making a good domestic coke in view of the fact that the many Illinois coals make a better domestic coke and show less loss of volatile matter.

The markets for the Iowa coal are largely local, although some coal is shipped into eastern Nebraska. A considerable amount of Illinois coal is shipped into Iowa and on the south the Illinois and Missouri coals prevent Iowa coal from moving in that direction. Colorado coal enters western Nebraska and, in fact, overlaps the Iowa markets in that state. On the east, the Iowa coal is hemmed in by the cheaper and better Illinois coals which are shipped up the Mississippi Valley. —U. S. Bureau of Mines Technical Paper 269.

Handling Coal with Horse and Drag Scraper

By H. A. Ward

FEW small plants have modern coal handling equipment. Many plants using a car of coal a day are dependent on hand labor for all coal handling. Where space is available, the practice of storing part of the year's supply during the spring and summer is becoming common. Even where small plants have coal handling equipment in the plant, they depend on hand labor at the storage pile. Under such conditions, the cost of handling increases rapidly with the size of the pile, due to the necessity of cutting back.

The method of using a horse and scraper, as developed by the writer, could be profitably employed by many plants. A drag scraper of light construction with a capacity of 7 cu. ft. will prove the most satisfactory for this work. This will require about six trips per ton. The investment for the scraper will be about $15.

Under the conditions we have met with, two men with a horse and scraper can unload, from hopper cars such as shown in Fig. 1, and store from 50 to 100 tons of bituminous nut and slack or anthracite screenings per day of 8 hr. The amount per day between these limits depends on conditions, on the pile, on how carefully the work is organized, and how persistently the men keep at the task. If the men were paid on a tonnage basis, I believe the average handled per day would exceed 75 tons. With the type of car shown in Fig. 1,

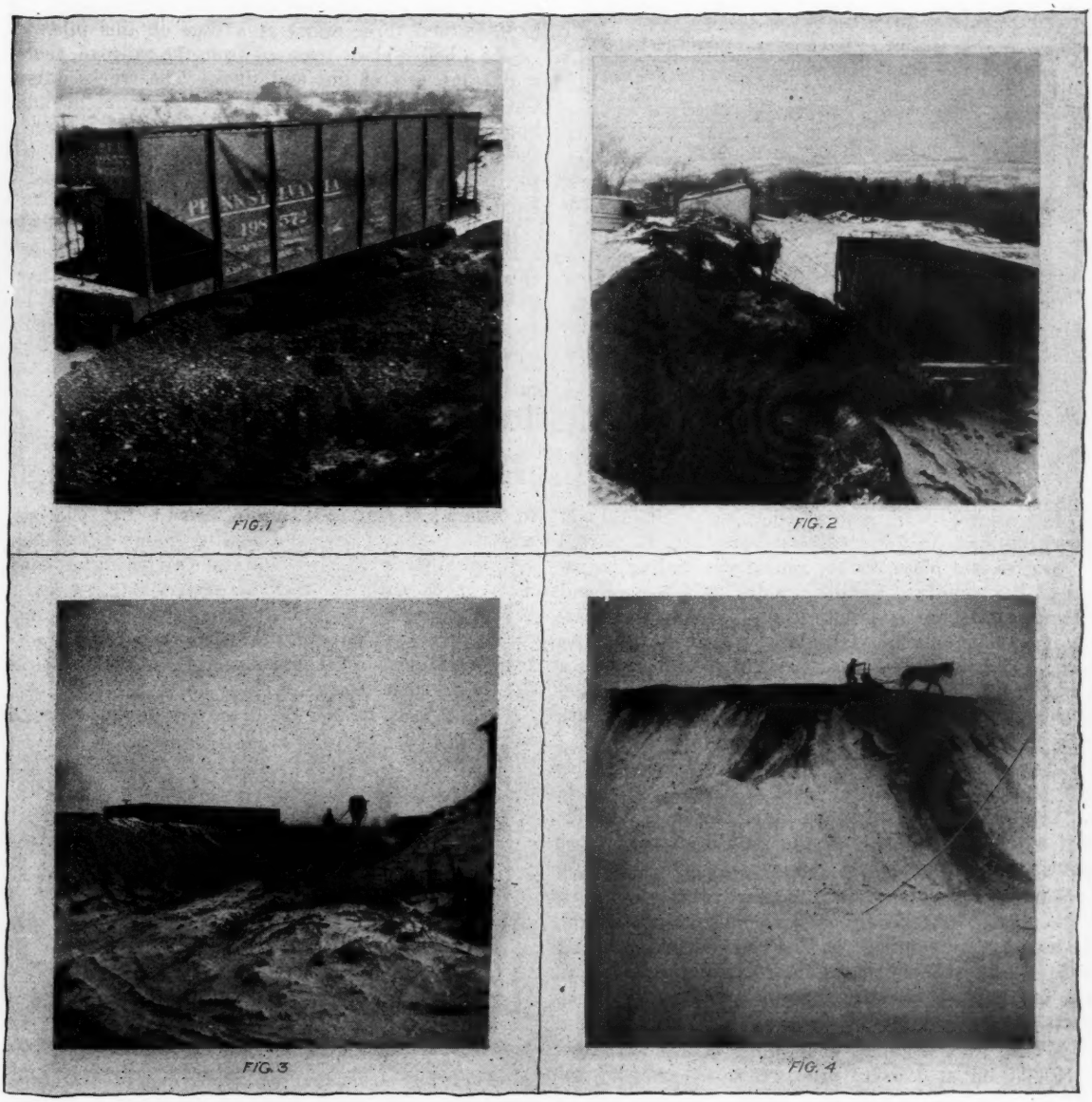


FIG. 1 FIG. 2

FIG. 3 FIG. 4

FIGS. 1, 2, 3 AND 4. ILLUSTRATING METHODS OF HANDLING AND STORING COAL WITH A DRAG SCRAPER

one good man will keep the coal flowing from the hoppers as fast as his partner and the horse can take it away.

FIG. 5. CAR OF SCREENINGS DIRECTLY BACK OF MAN AND HORSE

Figure 2 shows how the coal flows from the hopper into the path of the scraper. This car is nearly empty. Usually there are piles at both hoppers. Figure 3 was taken from a position at the left of Fig. 2. At the present writing, the pile hides the car from camera position, Fig. 2.

Figures 1, 2 and 3 show method of storing on our nut and slack pile, which is on ground level with the track. Across the track the ground slopes away very rapidly, and here beginning at the track out we have stored 3000 tons of anthracite screenings. Figure 5 shows a car of screenings in front of the building directly back of man and horse. Figure 4 shows the breast of this screening pile with the scraper dumping at the shoulder. By proper manipulation of the scraper, the coal is rolled down the embankment. We have worked three crews at a time on this pile.

At a boiler plant removed from the railroad, there is a 1000-ton pile of nut and slack. The trucks dumped the coal as high up the pile as they could go and a horse and scraper carried it from there to the top of the pile. In case the storage pile is located just outside the plant, it can often be economically reclaimed by horse and scraper.

Just a word of caution, *do not use a horse which is sharp shod.* The above grades of coal when handled in this way give a better footing for the horse than a plowed field. The footing where a scraper has been loosely dumped is a little soft, but in no way troublesome.

Power Plants for Canneries

LARGE QUANTITIES OF STEAM REQUIRED IN THE CANNING INDUSTRY ARE FURNISHED BY MODERN BOILER PLANTS. BY CHARLES W. GEIGER

THE GRADUAL but steady development in the art of canning and preserving food products has served to give it a place, today, among the leading industries of the country. Canning, today, is a science and in the modern cannery practically all cooking and heating of food products is regulated automatically. As can be imagined, the large batteries of cookers in such a plant, require large quantities of steam and as a consequence, the power plants which furnish this steam are by no means small.

The purpose of this article is to acquaint the reader with modern practice in this field of power plant work, and the following descriptions of plants on the Pacific coast will serve to illustrate the typical characteristics common to installations of this type.

Starting at Oakland, Cal., the first plant on our list is the plant of the Western Canning Co., a photograph of which is shown in Fig. 1. The boiler room is directly across the street from the cannery and, as may be seen, is a building of brick construction, measuring 40 by 88 ft.

A 6-in. line, installed in a tunnel under the street carries steam at 125 lb. pressure to the cannery for cooking purposes. Condensate return lines are also installed in this tunnel. The tunnel being sufficiently large for a man to walk through, renders all piping easy of access for inspection or repair purposes at all times.

Five 150-hp. return tubular boilers generate steam at a pressure of 125 lb. per sq. in. Oil is used as fuel and the oil pumping and heating equipment consists of an extra heavy semi-steel oil heater and two 4½ by 2¼ by 4-in. duplex pumps; the body of the heater tapers off to form a self-contained base to fasten to the foundation, and also acts as a filter and settling chamber for all dirt, sand and water that precipitates from heating the oil. This can be blown off while the system is in use and under pressure, the equipment thus being self-cleaning.

A copper coil in the heater heats the oil to the proper temperature with exhaust steam from the oil pumps,

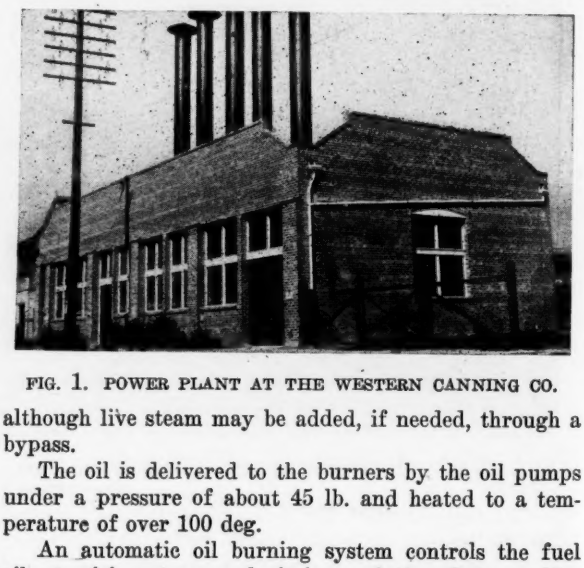


FIG. 1. POWER PLANT AT THE WESTERN CANNING CO.

although live steam may be added, if needed, through a bypass.

The oil is delivered to the burners by the oil pumps under a pressure of about 45 lb. and heated to a temperature of over 100 deg.

An automatic oil burning system controls the fuel oil, atomizing steam and air in a relation that provides correct combustion and results in the following important advantages: maintenance of uniform steam pressure under extreme load variations, maximum economy

in fuel oil consumption, elimination of smoke and increased capacity of boiler plant.

Water for various uses around the cannery is obtained from a dug well. There is installed a 40,000-gal. surge tank and a 30,000-gal. supply tank, the latter being supported at a height of 70 ft. The water is pumped from the well and delivered into the surge or settling tank by a non-pulsating deep-well plunger pump. The brass working barrel of the pump is placed down in the well 120 ft. from the surface. It has a capacity of about 4500 gal. per hour and is belt-driven by a 10-hp. electric motor.

Control of Cooking Temperatures

This power plant supplies steam for 12 lines of cookers, and exhaust boxes.

There is no single factor in the canning industry which is of more importance than the accurate and uniform control of the temperature of the steam in the cookers, and exhaust boxes. The Western Canning Co. was among the first of the industry to recognize this fact and has installed thermostatic regulators for the control of the temperature in all the cookers and exhaust boxes.

Automatic control of temperature in cookers not only saves fuel, and maintains the product uniformly at the highest quality but takes the variable "human factor" out of the most important operations in the canning industry—it is a safety factor guarding against possible heavy losses, and insures the dependable operation of every cooker, exhaust box, etc.

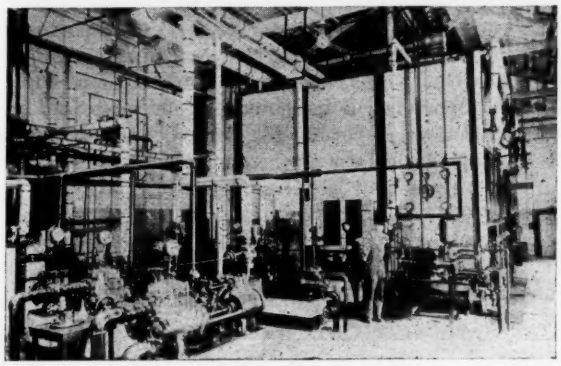


FIG. 2. INTERIOR OF A BOILER ROOM AT A MODERN CANNERY

The principle of these controllers is the same as that which has been used for the control of temperature on heating and ventilating systems for the past 35 yr., but, to meet the individual conditions of the canning industry, has been slightly modified.

It is not difficult to understand the many advantages of automatic control over the manual regulation, as human agencies, through negligence or ignorance, are irregular and cannot be depended upon when it is of paramount interest to maintain uniform temperature. In any plant where temperature is controlled automatically, there is a saving of steam and consequently of fuel amounting to from 20 to 35 per cent.

The controlling system installed is a pneumatic system and consists of a calibrated thermostat and siphon diaphragm valve for each unit, together with a valve in the steam line which opens or closes by compressed air, which in turn is automatically controlled by the thermostat.

Compressed air is provided by an electrically operated air compressor mounted overhead which supplies air at 15 lb. pressure. The air compressor is provided with an automatic electric governor which starts and stops the motor as the pressure falls or rises.

The calibrated thermostat is inserted into the cooker, or exhaust box in such a manner that only the element affected by the temperature is exposed to the control medium. The mechanism is left outside where it can easily be seen and adjusted when necessary. The thermostat is connected by small air piping with the siphon valves installed on the steam supply line. Like the

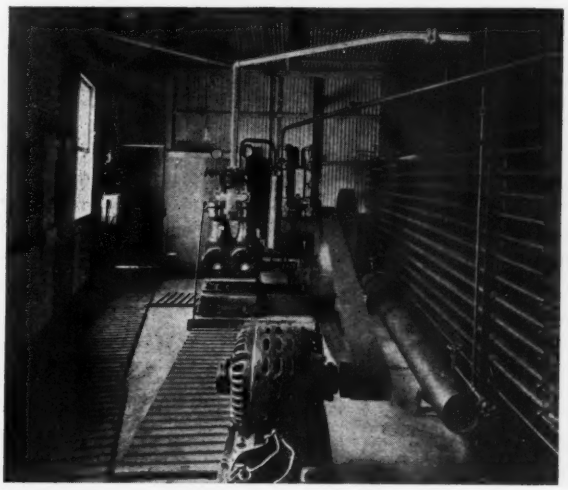


FIG. 3. REFRIGERATING EQUIPMENT INSTALLED IN A CANNERY

thermostat, the siphon valve is entirely of metal, having no rubber diaphragms to vulcanize and grow hard.

For the canning industry the valve has been constructed to operate against a steam pressure of 125 lb. per sq. in. The compressed air which operates the valve is admitted to the case surrounding the bellows and acts upon the outside of the bellows instead of upon the inside. This reduces the air space in which the bellows operate to a minimum and saves much air which otherwise would be wasted in operating the valve. Each of these temperature control valves operates many thousands of times during each canning season, and has sufficient lift or motion in the diaphragm to insure the valve opening wide. It is powerful enough to close off the steam tightly, thus preventing wiredrawing and cutting of the valve seat. It has reserve power to close the steam off in spite of small particles of dirt that wash down and lodge in the valve seat.

Libby, McNeil & Libby Plant

Another large plant of this type is that of Libby, McNeil & Libby at Sacramento, Cal. This plant includes a very extensive power plant, for supplying steam and compressed air throughout the cannery.

The boiler house consists of a concrete and brick building 40 by 60 ft., in which are installed two batteries of water-tube boilers with a total of 600 hp. and three return tubular boilers, with a total of 270 hp. The

chimney is of concrete 12 ft. in diameter at the base and 4 ft. in diameter at the top, the height of the chimney being 126 ft.

Oil is used for fuel, the oil being stored in two steel oil storage tanks buried under the ground just outside the boiler house. One of these tanks has a capacity of 15,000 gal. and the other 20,000 gal.

The oil pumping apparatus consists of two duplex oil pumps mounted on an iron stand, with heater, air chamber, and oil strainer, the pumps being so arranged that either pump may be removed for repairs while the other is in use. After heating the oil by exhaust steam it is pumped to the burners, where it is atomized by steam. Compressed air is used for atomizing the oil, when starting fire under cold boilers.

There is a special air compressor and pump room built in connection with the boiler house, and over the compressor room are the transformers and other equipment of the local public service company which furnishes all the electricity used in operating the various motors and in lighting.

In addition to the two compressors in the compressor room there is also installed a vacuum pump driven by a 5-hp. motor. Vacuum is used in connection with the can-sealing machines.

Two water pumps of the horizontal type, belt driven by individual 15-hp. motors, and one eight-stage centrifugal pump which is driven by a 25-hp. vertical motor furnish water for use in the cannery. The centrifugal pump is located at the bottom of a well 160 ft. below the surface of the ground and delivers water to a 50,000-gal. steel water tower. An air lift pumps water from a 220-ft. well into a 2500-gal. reservoir, the two horizontal pumps pumping from this reservoir into the steel water tower. For use in case of emergency, connections are made with the city water supply.

Steam is supplied for the following equipment: Eleven exhaust machines, 10 cookers, four retorts and nine 1000-gal. tanks. The tanks are used for the preparation of catsup and are equipped with copper coils of various sizes; some of them are equipped with open steam pipes. There is also a 1000-gal. glass lined tank, also equipped with copper steam coils. The latter tank will cook a 600-gal. batch, reducing it to 280 or 300 gal., in about 30 min. under favorable conditions, the time required depending upon the grade and condition of the raw products. Steam is also supplied for one 1200-gal. and two 200-gal. vacuum tanks used for reduction purposes and to seven steam-jacketed open reduction kettles which are used for mixing soups.

Controlling Combustion

STUDY OF FURNACE EFFICIENCY APART FROM BOILER EFFICIENCY. CONTINUOUS GAS ANALYSIS TO SHOW EXCESS AIR AND COMBUSTIBLE GASES IN THE FLUE AS WELL AS CO_2. BY GEO. H. GIBSON

HEAT is lost up the chimney in two distinct forms, namely, the sensible heat of the entire volume of flue gases, and the heat represented by the chemical energy in unconsumed combustible gases. The amount of the sensible heat depends on the temperature and the volume of the flue gases. The amount of heat lost in the form of chemical energy depends on the heat of combustion of the unconsumed combustible gases and their volume.

To burn fuel completely there is always necessary a surplus of air over what would be theoretically correct. The amount of this surplus varies constantly, depending upon the many different factors that influence combustion. But maximum efficiency under practical conditions is attained when there is just enough surplus air to make complete combustion possible, that is, combustion without the escape of combustible gases up the stack. It is that condition where a reduction in the air supply results in incomplete combustion, and an increase in the air supply results in unnecessary waste of energy through the carrying away of sensible heat by excess volume of flue gases.

An idea of the magnitude of the fuel losses due to the escape up the stack of combustible gases when the air supply is insufficient as compared to the losses due to the presence of excess air may be gained by a comparison of the curves in Figs. 1 and 2. In Fig. 1 we have a curve showing the fuel losses which take place with varying percentages of CO_2 (varying inversely with the excess air supply) in the flue gases, when there are no combustible gases present. However, combustible gases (CO, CH_4 and H_2) are bound to begin to form at some point as the percentage of CO_2 is increased (air supply decreased) and losses due to the formation of these combustible gases are far greater in proportion to their volume than losses indicated by equivalent proportions of CO_2. This is graphically illustrated in Fig. 2, where the portion CB in the curve represents fuel heat losses that develop beyond the point C where combustible gases begin to form as the percentage of CO_2 is still further increased by reducing the air supply.

The point C is the critical point. It is the point where combustion takes place with the greatest economy in fuel consumption. It varies not only in different furnaces, but varies constantly in the same furnace.

THE STORY THAT CARBON DIOXIDE AND COMBUSTIBLE GASES IN FLUE GASES TELL

MANY power plant engineers make it a general rule never to allow the CO_2 present to exceed 10 to 12 per cent. Others put it as low as 8 to 10 per cent. Under these conditions, there is likely to be a great waste of fuel due to the avoidable escape of sensible heat up the chimney. In contrast with these there are authorities who claim there is no danger of having combustible gases escape unconsumed before CO_2 reaches a point above 15 per cent.

The fact of the matter is, combustible gases may appear with any percentage of CO_2, and depending on CO_2 records alone may therefore be misleading. It is quite possible to have large volumes of combustible gages (CO, CH_4 and H_2) present simultaneously with a low percentage of CO_2 as well as with a high percentage of CO_2. For example, if the fire in one part of the furnace is very thick or dirty, CO would be generated in that part and escape unburned because not enough air

would be going through. If, at the same time, there is an air hole in another part, air would rush through there unused. Under these conditions CO would be found present at the same time that the record would indicate excess air by a low CO_2 reading.

Insufficient air supply is the most general cause of the presence of CO in the stack. CO may, however, be present due to the poor design of the furnace, improper methods of firing, the coal being of a character not

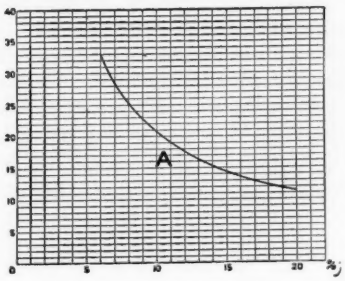


FIG. 1. VARIATION OF CO_2 WITH AIR SUPPLY, NO COMBUSTIBLE GASES PRESENT. IDEAL CONDITION

adapted to the equipment with which it is burned, poor mixing of the combustible gases with the air and low furnace temperature, which causes gases to be cooled below the ignition point before combustion is complete.

Unheeded Facts About Combustion

Oxygen used in the process of combustion in a furnace comes from two sources, namely, the primary and the secondary air supply. The primary air supply is that which flows through the combustible material in the fire bed. The secondary air supply is that which is admitted to the combustion chamber above the fire through holes in the fire bed, the fire doors, through

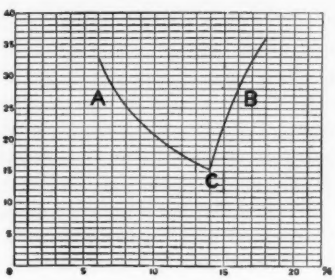


FIG. 2. RELATION OF CO_2 TO AIR SUPPLY WHEN COMBUSTIBLE GASES APPEAR WITH CO_2 OVER 14 PER CENT. USUAL PRACTICAL CONDITION

leaks in the boiler settings, etc. It supplies the free oxygen necessary to oxidize the combustible gases generated in the fire bed.

Contrary to the generally prevailing impression, the volume of the secondary air required to burn coal in a furnace is greater than the volume of the primary air. If the coal were all carbon, the volume of the secondary air required under ideal conditions would be the same as the volume of the primary air. In the first stage of combustion the reaction would be $2C + O_2 = 2\ CO$. In the second stage it would be $2\ CO + O_2 = 2\ CO_2$. In other words, the volume of air required to convert

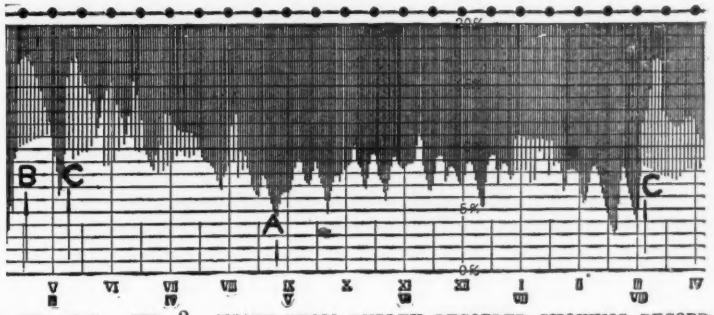


FIG. 3. CHART FROM DUPLEX RECORDER SHOWING RECORD OF CO_2 AND COMBUSTIBLE GASES

the carbon into CO in the primary stage is the same as the volume of air required to burn the CO into CO_2 in the secondary stage. But there are other gases than CO which come off in the first stage of burning coal. To burn these additional gases, secondary air is required. Inefficient mixing of the combustible gases in the combustion chamber with the secondary air supply gives rise to still further demands for excess secondary air, that complete combustion may take place. How much secondary air is required depends on the furnace design, kind of stoker, method of firing and kind of fuel.

Nobody can tell anything about the volume of the secondary air, where it all comes from, how much enters through the various known channels, or what its proportion to the total air supply is. It is generally recognized, however, that the one safe rule is to keep it at the minimum necessary to insure complete combustion of combustible gases. This can be done only by a constant watch for the appearance of combustible gases in the flue, while holding the percentage of CO_2 at the maximum point which can be maintained without the appearance of such combustible gases.

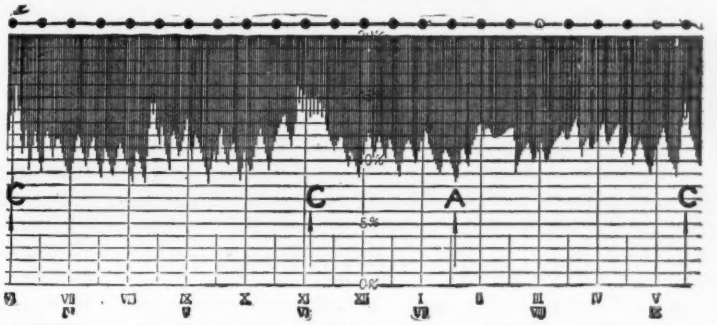


FIG. 4. DUPLEX RECORD AFTER ALTERING FURNACE ARRANGEMENT AND FIRING METHODS TO SECURE COMPLETE BURNING OF COMBUSTIBLE GASES

To achieve efficient furnace results, some clear, simple means should therefore be provided for telling him just how much excess air is present at all times, and to give him prompt warning of the appearance of combustible gases in the chimney. Such means act as a guide for the fireman, enabling him to regulate his fires intelligently and to manipulate to the best advantage the controllable elements which determine the admission of excess air to the combustion chamber.

The best method of firing a particular furnace, and regulating the air draft and dampers, can be determined only by trying various ways and means and carefully

watching the results recorded from the analysis and recording of both CO_2 and combustible gases. Only through such a procedure can the fireman learn by experience what must be done, and what must be avoided to give the maximum percentage of CO_2 at all times without the loss of combustible gases up the flue.

Correct mixing of the air and the volatile combustible products of the furnace is a matter of great importance, and represents one of the most difficult problems of design the combustion engineer has to contend with in his efforts to cut down the amount of excess air necessary to insure complete combustion and to reduce the possibilities of having unconsumed combustible gases escape up the chimney. Stratification, having the process of mixing take place too slowly, or premature cooling of the mixture below the ignition point—all lead to waste.

How nearly combustion in practice can reach the ideal is well represented in certain boiler plants where blast furnace gas is the fuel. By means of a multiplicity of interspersed small air and gas orifices such a

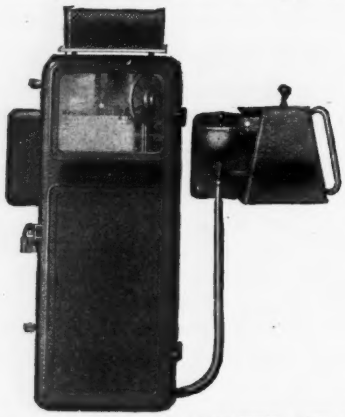


FIG. 5. THE DUPLEX GAS ANALYZER AND RECORDER

thorough, intimate mixture of the fuel and air is obtained that the percentage of excess air necessary to insure complete combustion has been reduced practically to zero. On the other hand, it is not at all uncommon to find in small coal burning boiler plants where hand firing is used, that the CO_2 in the flue gas analysis registers as low as 4 per cent, showing the presence of 420 per cent excess air.

Essentials in Combustion Control

By continuously recording the percentage of CO_2 as an indicator of the amount of excess air present, and also detecting and clearly recording the presence of combustible gases (CO, CH_4 and H_2) immediately they are present, effective combustion control can be established.

Graphic records of such a combination of simultaneous gas analyses, considered in conjunction with other records and the various functions in boiler room operation, not only point the way toward improving combustion in a given furnace, but are also an indispensable guide when, to improve combustion, alterations or reconstruction of a furnace are considered. At such times, the grate, combustion space, baffles, arches, wing walls, dampers, settings, chimney or mechanical draft, etc., all come under consideration.

Recently an instrument has been perfected and placed on the market, which not only accurately analyzes and records the percentages of CO_2 present at all times in flue gases, but also promptly detects and clearly records on the same chart the presence and the approximate proportion of combustible gases whenever they appear.

One of the prime purposes of this instrument is to detect the presence of combustible gases in the flue immediately upon their appearance, and to record accurately the percentage of CO_2 present at that particular time. It will detect and record with the least possible delay the presence of as low as one-tenth of one per cent of combustible gases in the products of combustion. The presence of combustible gases once established, the accurate determination of their actual percentages is not of any importance. The instrument indicates approximately the degree in which they appear, and that is sufficient for the guidance of the fireman. The actual percentage present is rarely less than two-thirds, or more than equal to the amount recorded on the chart.

Figure 3 represents a diagram made by one of these instruments. The lower contour of the diagram represents the percentages of CO_2 present at all times. The lighter areas in the diagram indicate the presence of combustible gases CO, CH_4 (methane) and H_2. The proportion of combustible gases present is roughly indicated by the height of the lighter areas at any particular time.

Looking at this diagram, it will be seen that at the point C farthest to the left, about 5:15 a. m., combustible gases began to form when the per cent of CO_2 was 10, and the amount of combustible gases formed increased rapidly, as the percentage of CO_2 increased to 11 per cent at 5:45, only to vanish again when the per cent of CO_2 was again reduced to 10 per cent at 7:30. At point C to the right, 3:10 p. m., combustible gases begin to form again, this time, however, when CO_2 is only 8½ per cent. This shows that morning and afternoon, changes have taken place in the furnace conditions such that while combustible gases began to form when CO_2 was 10 per cent early in the morning, they began to form when CO_2 was only 8½ per cent in the afternoon. Should the operator keep CO_2 at 10 per cent all day long, it is evident that serious losses might take place as in this case between 3 and 4 o'clock in the afternoon, as indicated in the right-hand part of the diagram.

Figure 3, which we have just discussed, shows the condition found in a boiler plant at the time the instrument was first connected. Certain changes were made in the furnace, the nature of the fuel and the method of firing, with the result that conditions as illustrated in Fig. 4 were obtained. In this diagram it is seen that CO_2 could be carried to a point as high as 13 per cent without the formation of CO. In other words, the critical point was raised several points higher on the diagram, the reduction in air supply without formation of combustible gases resulting in a saving of 20 per cent in fuel. With such a record always before him, the operator is always in a position to follow closely any variations in the positions of the critical point and knows immediately when combustible gases begin to escape unburned up the chimney. Where the dark con-

tour goes below the critical point, too much air is supplied, or there is improper distribution of air. Where, on the other hand, the dark contour rises above the critical point, that is, the point where light areas begin to show, the supply of air is insufficient.

Combustion Control Instrument

The apparatus, Fig. 5, is driven by water pressure of about 10 lb. per sq. in. Before entering the instrument, the gas samples from the flue are pulled through a filtering system, which removes all traces of soot and dirt, and are then drawn into and forced through the apparatus by a mercury piston. There are no mechanical valves, such functions as these ordinarily fulfill being performed by various kinds of mercury seals and traps.

Samples of gas are forced alternately through two routes; one leading directly through a caustic potash tank where CO_2 is absorbed, and the other first through an electrically heated furnace wherein the combustible gases are oxidized to CO_2 and H_2O, and then through the caustic potash tank. Samples that are forced through the caustic potash tank give the readings only for CO_2. Those that are forced first through the electrically heated furnace and then through the caustic potash tank, give readings of CO_2 plus combustible gases. The difference between any two successive readings is proportional to the amount of the combustible gases present at the time the analyses are made.

In the electrically heated furnace, the oxygen necessary to oxidize the combustible gases, CO, CH_4 and H_2 to form CO_2 (which is later absorbed in the caustic potash tank) and water (which is condensed) is usually taken from the air which is almost invariably present in flue gases, even when combustible gases are present. When such free oxygen is not available, oxygen is taken from copper oxide provided in the furnace for that purpose. The copper oxide, however, probably seldom acts as anything but a catalytic agent and need never be renewed.

Should any of the copper oxide be reduced to plain copper in oxidizing combustible gases in the process of analysis, it is reoxidized by oxygen present in the flue gas samples passing through the electric furnace later.

To diminish the lag between the times when the gas leaves the flue and the analysis is recorded on the chart, small communicating tubes are used, reducing this lag to about 3 min. where the distance between the instrument and the point where the flue is tapped is about 60 ft. and the instrument is making about 40 analyses per hour.

The recording pen, when at its highest position, comes into contact with an ink container having a two weeks' supply of ink, so that the ink in the pen is automatically replenished every time it returns to the high point on the chart.

The apparatus requires attention only in winding the clock once a week, replacing the caustic potash solution two or three times a month, replenishing the ink supply twice a month, and putting in new rolls of paper once every two months.

Accuracy and Value of Records

Readings indicating the presence of combustible gases are exaggerated, if anything, by the instrument, which is an advantage as a danger signal. The losses due to the appearance of combustible gases are much greater than the savings due to an equivalent increase in CO_2 as registered on the chart, and an exaggerated record of their presence on the chart has a favorable effect on the fireman. Since it is aimed never to have combustible gases present at any time, there would be no object in having exact records of the percentage present where they do appear. An approximate, and preferably an exaggerated record, is all that is necessary, and this is the kind of record made by this instrument.

The CO_2 records of the machine are accurate, which makes possible the accurate determination of the critical point at any time under any conditions. The critical point, C, as mentioned before, is the highest percentage of CO_2 that can be reached in a given furnace without having combustible gases appear. The higher it can be raised, the more economical is the process of combustion. Knowing its maximum from the records of the instrument, the fireman can always tell the degree to which he is approaching ideal conditions. Should combustible gases appear at a point below the critical point, he knows that his dampers, fire doors, or the fire itself need immediate attention, which experience soon teaches him to give to the best advantage.

The plant executive is given a permanent record which gives him the data necessary to compute the degree of efficiency attained in the firing of the furnaces, and offers him every opportunity to appreciate the efforts of the firemen. It enables him to give valuable suggestions and advice and to co-operate with the boiler room force most effectively towards promoting fuel economy.

How to Get Your Suggestions Across

By K. Rankin

With industrialism quiet as it is at present, a good opportunity exists to make long-needed improvements in the plant and overcome depreciation that had to be foregone during the haste of war and the prosperity that followed it. Unfortunately, money is so tight and things appear on the surface to be so uncertain (which in reality they are not, of course) that it is difficult to obtain permission to spend any money except what is absolutely necessary.

Everybody seems to be "playing safe." This is one reason why many engineers are keeping quiet and refraining from making suggestions and recommendations for new equipment or repairs. They feel dubious as to the way such recommendations would be accepted. They prefer to keep silent rather than risk their jobs. It is doubtful if there is need for such caution, however.

Too many executives appear to think that once a good engineer is chosen for the job, the power plant should then be able to run itself. If requests are made for new parts and different apparatus, these executives immediately assume that the engineer is endeavoring to save himself work and trouble. The request is turned down flat. Many good and justified recommendations are advanced by capable men in this way, only to receive the same treatment. Thus, as length of service increases, the engineer who once was so enthusiastic, optimistic

and alert, becomes reconciled, less interested and gradually lets things go along as they are.

In ninety-nine cases out of a hundred the real trouble is that the engineer making the recommendations is not a salesman. He is a good engineer and knows his business and much besides. He may even be a strategist; he may even be a diplomat; but he lacks that something that makes him a salesman.

The secret of salesmanship consists of convincing your prospect that he wants and needs what it is that you have to sell. It is here that the engineer generally fails. He fails partly because he does not use the best strategy, enough diplomacy, the right policy and, lastly but perhaps most important of all, because he has not the proper viewpoint of the man he must "sell."

Preparing Your Brief

A sales campaign, whether for a stoker, a soot cleaner or an instrument, must be planned. The planning is done in almost the inverse way to which the presentation is finally made. Most engineers, as they must to satisfy themselves, start off with a hypothesis which they develop and finally prove to their own satisfaction. Then they have proven their case. It is the proof in which the executive is invariably concerned.

Make sure of your facts. "I think so" is not enough. You must be able to say, "This is so" or "I can prove it" or "This is the actual result being obtained in Mr. So-and-So's plant, where conditions are identical with our plant." Nothing is more convincing than actual experience elsewhere. "Elsewhere" should preferably be in some neighboring plant—that of a competitor if possible. This strikes very close to home in the heart of your superior and awakens a keen sense of rivalry as well as the appreciation of wise business.

Most engineers are proud of their plants. Through local meetings of lodges and societies, keep up acquaintances with fellow engineers. Visit their plants and ascertain what are their problems and how they meet them. You owe this to yourself as a progressive engineer; this knowledge may be vital to you as a salesman. Every engineer is delighted to show his plant to visitors, especially when those visitors are the executives of a neighboring plant who have come because they have heard complimentary facts about the way he runs his plant.

Visits such as these have put over many a deal that would otherwise have died a natural death because they sounded too theoretical or Utopian. The strategical engineer considers neighboring plants' salesmen to help him.

The Presentation

Be optimistic and enthusiastic, but bottle these feelings up until they have had time to season. A proposition that looks too good causes suspicion. The executive is accustomed to consider 15 per cent a good return; he grows dubious when you talk about 50 to 100 per cent return on the investment, rates of interest quite common in the power plant.

You cannot afford to go off half cocked with a half-baked idea. One mistake will spoil everything and hinder future effort for perhaps years. Not only cannot you afford to be wrong in your presentation but you cannot afford to miss a single telling point in your brief. Gather your facts; check them up; arrange them in natural sequence so that your argument can be followed easily by those who know less about your end of the business and are often almost entirely ignorant of it. Every page of your report should strike home.

Two heads are better than one. Unless you are accustomed to making reports, drawing up estimates and calculations, it is well to have a friend go over your report, to check up its accuracy if not also to give suggestions. The looker-on often sees most of the game. You may be so close to your problem that you may omit facts that may be determining factors when the crucial test arrives. When all is in good shape, have the report typewritten if possible and neatly arranged.

Sales Psychology

The first blow often wins the fight. The opening paragraph of a sales letter may decide the issue. Arouse the attention and interest of your reader. Then hold it.

Money saving is the crux of the situation. It is the executives' first problem, although it may assume many forms such as coal consumption, boiler shut-downs, labor force, time required, etc. Your boss is concerned with what things cost; you are concerned how these things are done. The executives' problem is money—yours its equivalent, men, machines, materials. Therefore, start off your sales talk in terms of dollars and cents.

You can save so much by doing so and so. The initial cost is so much, the saving pays this off in so many months. The rate of return is, therefore, 50 to 100 per cent or whatever it is, depending upon the amount of fuel burned, its cost or whatever is involved.

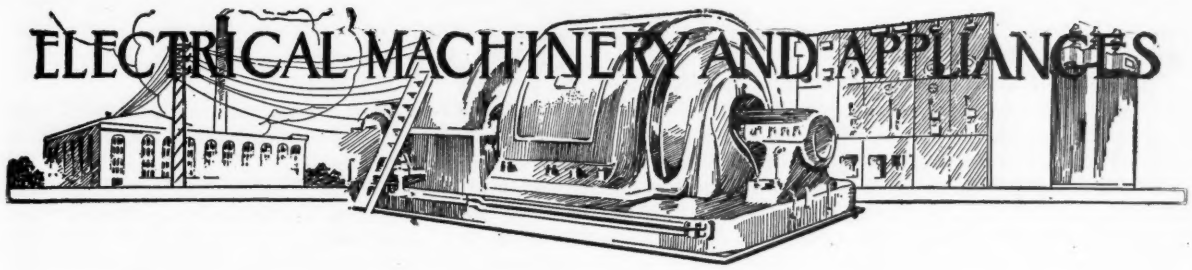
Most boiler-room apparatus can pay for itself in one year; much less time is required in many cases. No other investment pays such a high rate of interest with such security. You need have no diffidence nor hesitancy in selling gold-edge securities that are tax free. No executive worthy of the name can afford not to listen nor fail to be interested, if the proposition is properly laid before him at the proper time.

Short-circuit the technicalities and the engineering details of how the process is performed and the apparatus works. That is beside the point. Tell the executive what the apparatus will do in the way of lower costs, more rapid work, fewer men and reduced labor turn-over. Money speaks. Therefore, convert your problem to a dollar and cent basis and you will hit the executive you aim to sell squarely between the eyes.

Selling is not mysterious. Too much has been said about psychology and personality and presence. The secret is to convince your prospect that you are selling what he needs and what he needs in the worst way. Every executive needs to save money now. Every cent saved is a cent made. Prove that your suggestion will save money and you have won your case.

At a meeting of the town council of Landrum, S. C., held recently, it was unanimously decided that the town would no longer take lighting power through the Tryon Electric Service Co., but would put in its own plant and have its own system. A committee was appointed to take the matter in hand at once.

Never contrive to make it easy for your concern to get along without you.—Forbes Magazine.



Remodeling Switchgears for Power Systems---V

CHANGES MADE IN PLANT, CAPACITY OF WHICH INCREASED FROM 1500 TO 24,750 KV.A. BY STEPHEN Q. HAYES*

ON still another system, panel space was the limiting feature, as the station contained a long distributing board equipped principally with mechanically-operated remote-control small oil circuit breakers. The marble panels are located on the main switchboard gallery and the oil circuit breakers with the disconnecting switches and busbars are in the basement.

The company has practically reached the limit of available space for switchboard panels at this station, as there was only room for approximately two 32-in. panels at the extreme right-hand end of the a.c. switchboard.

The panels at the right-hand end of the a.c. switchboard comprised seven 24-in. feeder panels, and four 32-in. feeder panels. By changing the control of the various circuit breakers from hand to electric and still utilizing horizontal edgewise instruments, these eleven panels could all be reduced in width from 24 or 32 in. to 20 in., thus making a total saving in space of 76 in. and providing space for four additional 20-in. panels, each controlling two circuits or a total of eight feeders.

If the company uses 7-in. diameter round pattern meters, the width of all of these panels can be reduced to 16 in., making a total saving in space of 120 in., permitting the installing of seven or eight additional 16-in. panels, each controlling two feeder circuits.

The various small breakers that are now mechanically controlled could probably be changed to solenoid control, the solenoids being located on the floor underneath the breakers, and attached to the operating rod that now runs down from the breaker to the bell crank on the floor. For the additional feeder circuits for which space can be readily obtained by the use of electrical control for the various circuits, an engineer would naturally recommend the use of solenoid operated breaker of suitable type, depending on the rupturing capacity desired.

The new circuit breakers with the disconnecting switches and framework can form an extension to the present equipment in the basement. When this equipment reaches the right-hand end of the basement, it will be possible to still further extend it by a right angle bend so that future breakers can be installed in the space underneath the present direct-current switchboard.

As still another example of rapid growth, a plant may be cited where the switching equipment furnished in 1912 was put in for the control of one 500-kv.a., 2400-v. turbo generator, one 1000-kv.a. turbo generator, and various feeder circuits. Hand control oil breakers were supplied of ample capacity for the plant as then contemplated. In 1914, a 3125-kv.a. turbo generator was installed. The switchboard was remodeled in 1915, breakers being changed to electrically operated and the remodeled switchboard controlled one 500-kv.a. turbo, one 1000-kv.a. turbo, one 3125-kv.a. turbo. A 5000-kv.a. turbo was later installed, the 500-kv.a. turbo has been replaced by a 3125-kv.a. unit, last year a 12,500-kv.a. turbo was furnished and consideration is now being given to the replacing of the 1000-kv.a. machine by a 12,500-kv.a. unit. In other words, this plant started

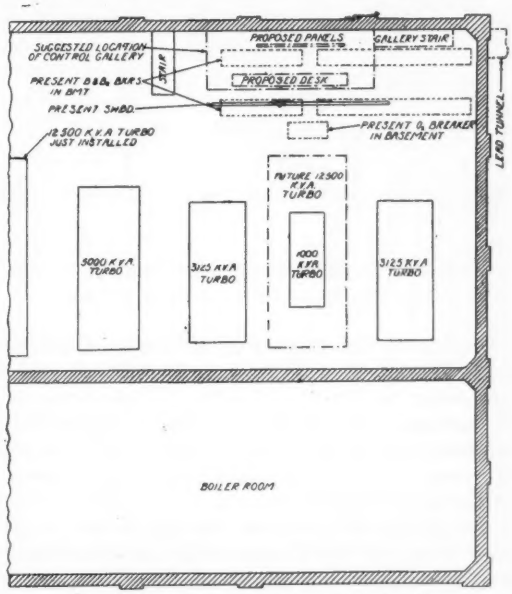


FIG. 37. PLAN VIEW OF STATION 4

with 1500 kv.a. in 1912 and had suitable switching equipment for such a plant. By 1915, the capacity had increased to 4625 kv.a., a 5000-kv.a. unit being added shortly afterwards. In 1919, the capacity had grown to 24,750 kv.a. with the probability of being increased to 36,250 kv.a. at an early date.

The original switchboard had mechanically operated oil breakers mounted in the space between the panel board and the wall. With the first remodeling, the original hand-operated oil circuit breakers were made electrically controlled, and removed from the space on the

*Electrical engineer, Westinghouse Electric & Manufacturing Co.

generator room floor back of the switchboard to an available location in the basement.

The contemplated second remodeling considers the location of the control switchboard, built in the form of a desk and placed on the gallery overlooking the generator room, the removal of the electrically operated breakers from the basement to a separate switch room, the changing of step-up transformers from indoor to outdoor type and the use of electrically operated outdoor breakers on the high tension side of the transformers in place of knife switches.

As shown in Fig. 37 the plan view of the power house, the present generator equipment comprises one 1000-kv.a., two 3125-kv.a., and one 5000-kv.a., 2400-v., three-phase 60 cycle turbo generators now operating, and a 12,500-kv.a. unit lately installed. Provision is being made for later replacing the 1000-kv.a. turbo generator by one of 12,500 kv.a. capacity.

The 12,500-kv.a. and the 5000-kv.a. units are so designed that at a later date they may be rewound for 13,200 v. and the new 12,500-kv.a. unit when installed, may be installed for either 13,200 or 6600-v. service.

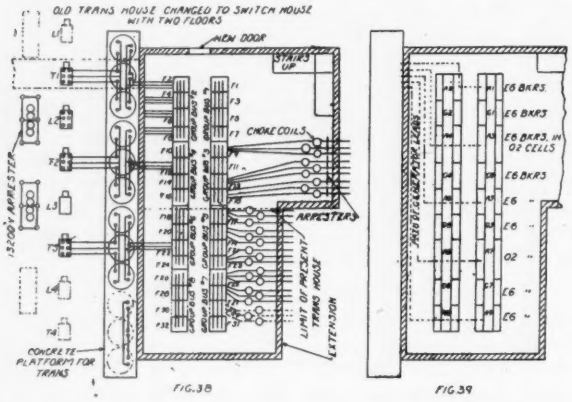


FIG. 38. PLAN VIEW OF TRANSFORMER HOUSE
FIG. 39. PLAN VIEW OF SECOND FLOOR

Outside of the generating station is a transformer house approximately 36 ft. long, 28 ft. wide and 20 ft. high, shown as Fig. 38. This transformer house at present contains three banks of indoor transformers, each comprising three units with a rating of 1000 kv.a. as self-cooled, 1800 kv.a. as water-cooled transformers. One of these banks steps up to 6600 v., the other to 13,200 v.; the remaining being a spare bank that can be used for either of these two voltages. All of the switching is done by means of breakers on the 2300-v. circuit of these transformers.

Figure 38 shows the transformer house as enlarged and modified into a switching station, and the three transformer banks changed for outdoor service, or three new banks each of about three 2000 kv.a. capacity have been indicated outside the switch house with space for a fourth transformer bank.

Outdoor oil circuit breakers have been shown on the high tension side of the three transformer banks and two outdoor breakers to be used for the present two high-tension transmission lines. Space has been indicated for the breaker in the fourth transformer bank and for two additional feeder circuits. The dot and dash line at one side of Fig. 38 shows the limit of the right of way for the pole lines and practically marks the property line available.

Figure 39 shows the plan view of the second floor of the switch house, this floor being directly above the floor shown in Fig. 38.

Figure 40 is an end elevation and sectional view through the switch house and outdoor transformer yard.

Figure 41 shows a single line diagram of connections where the oil circuit breakers have been marked to correspond with the numbering in the plan views, and where provision is made for a group system of supply.

Original Switchboards

The original switchboard furnished in December, 1911, was a twelve-panel board controlling the following circuits.

2—15-kw. 125-v. exciters.
1—500-kv.a. 2400-v. 3-phase turbo generator. (This has since been replaced by a 3125-kv.a. unit).
1—1000-kv.a. 2400-v. turbo generator. (This will later be replaced by a 12,500 kv.a. unit).
Various feeder circuits.

Switchboard was equipped with a 3-relay generator voltage regulator, 7-in. instruments, remote control oil switches for the generators, remote control oil circuit breakers for the feeders, the feeders being provided with 50, 200, 250 and 400-amp. ammeters. Blank panels were furnished for future exciter and future generator.

Panel 13 was furnished in May, 1913, the equipment for a 20-kw. exciter and for a 3125-kv.a. turbo generator equipped with 1200-amp. non-automatic oil circuit breaker.

In February, 1915, new panels and new equipment for remodeling the switchboard were supplied. With this new equipment a type "AE-4" board range regulator was furnished.

The Revised Switchboard

This was arranged to control two 15-kw., 125-v. exciters; one 20-kw., 125-v. exciter; one 25-kw., 125-v. exciter; one 500-kv.a. 2400-v. turbo generator that was later replaced by a 3125-kv.a. machine, one 1000-kv.a. turbo generator to be later replaced by 12,500-kv.a. unit; one 3125-kv.a. generator; one 5000-kv.a. generator; two power feeder circuits; one arc group circuit; four lighting circuits; two transformer banks of 1200-kv.a. capacity and eight new panels.

All of the hand-operated distant mechanical control breakers were furnished with solenoid mechanism to make them electrically operated. Solenoid operated breakers were furnished for the generator circuit to replace the distant mechanical control breakers and relays were supplied to secure definite time limit action in the feeder circuit.

Other equipment has been secured from time to time and at present there is installed a 22-panel switchboard.

The breaker and bus structure used with the breakers had a space left available for additional breakers that were to be used with a future 5000-kv.a. generator.

As the generator actually installed in 1919 is a 12,500-kv.a. unit instead of a 5000-kv.a. unit, the space left available in the structure was insufficient for the breaker needed with the new unit.

With the new unit was therefore furnished a 5000-amp. solenoid-operated-type oil circuit breaker. To allow this breaker to connect to either of the two sets of 2400-v. busbars a total of six 4000-amp. S.P.S.T. disconnecting switches mounted on porcelain pillars were furnished.

As shown in Fig. 37, the panel switchboard stands approximately 12 ft. from the side wall of the generating station and the center of the switchboard is nearly opposite the 1000-kv.a. unit. The solenoid operated breakers are arranged in two rows in the basement as shown by the dotted lines in the corner of the building near the panel board. The breaker for the 12,500-kv.a. unit has also been placed in the basement opposite the opening that was provided, with the idea that it would be large enough for the breaker needed for a future generator, assumed to be of 5000-kv.a. capacity.

The present solenoid-operated breakers similar to Fig. 4 were originally guaranteed for use in connection with an installation not exceeding 15,000 kv.a. Since

The present installed capacity consisting of one 1000-kv.a., two 3125-kv.a. and one 5000-kv.a. unit totals 12,250 kv.a. With the addition of the 12,500 kv.a. unit that is now being put in service, the generator capacity in this station will be 24,750 kv.a., this corresponding to a normal full load output of approximately 6000 amp. at 2400 v. three-phase. With a future 12,500-kv.a. unit installed in place of the 1000, the generator capacity in this station will be 36,000 kv.a., corresponding to a full load output of a little less than 9000 amp.

Assuming all of the turbo generator units to be of approximately 12 per cent reactance, such units would give eight times full load current in the case of short circuit at the end of 0.08 sec.; 4½ times full load current at the end of ¼ sec., three times full load current at the end of 2 sec., while the instantaneous short circuit might be in the neighborhood of 11 times full load current.

While all of the automatic breakers are provided with definite minimum inverse time limit relays and

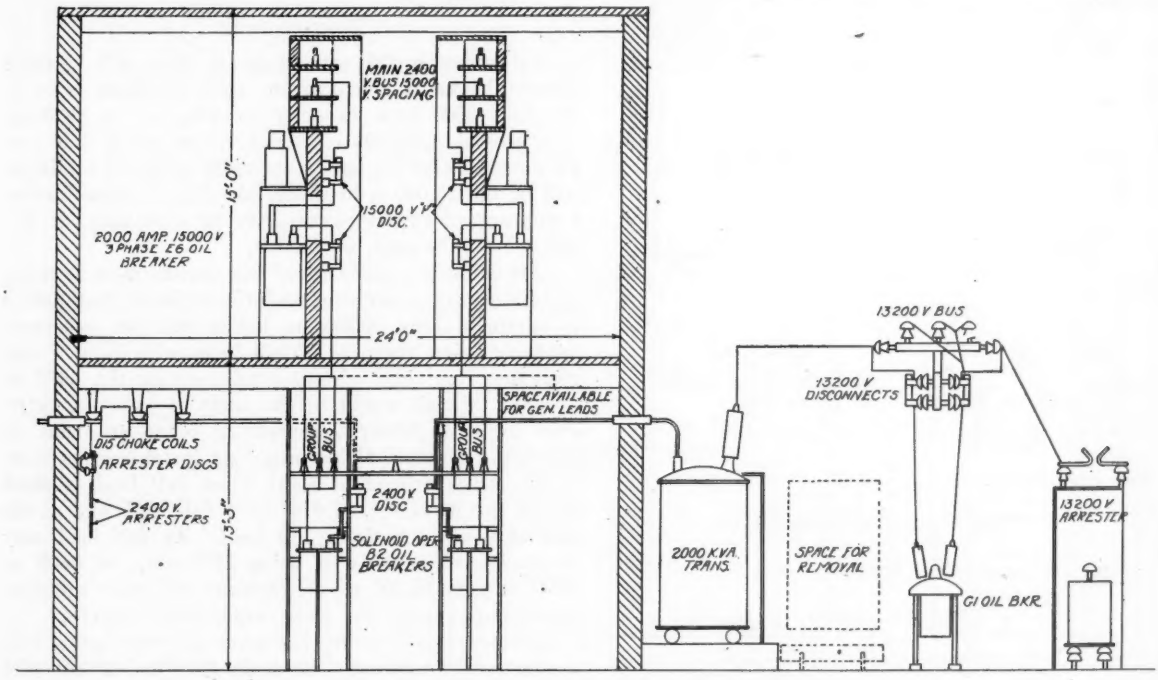


FIG. 40. END ELEVATION AND SECTIONAL VIEW

the time when this switching equipment was furnished, the rating of circuit breakers has been changed and the rating is now given on the basis of the ampere rupturing capacity that can be guaranteed for various units at various voltages.

The older breakers used in connection with certain circuits are now no longer in regular production, so their rupturing capacity has never been changed over to an ampere basis. These breakers, however, are practically equivalent to breakers of the 300-amp. size, guaranteed capable of rupturing 10,000 amp. at 2500 v.; and 600-amp. and 1200-amp. sizes guaranteed capable of rupturing 12,200 amp.

The 600—1200-amp. later breakers are guaranteed capable of rupturing 14,300 amp. at 2000 v., while the 1600 and 2000-amp. sizes are guaranteed capable of rupturing 11,000 amp. at 2500 v.

cannot be set to trip at less than about ¼ sec., the entire equipment is subject to the instantaneous short circuit strain caused by a short circuit current that might possibly be in the neighborhood of 100,000 amp. if the entire generator capacity were operating in parallel on one set of busbars, a decidedly unlikely condition. Probably the worst condition to be expected in actual practice would be between 60 and 75 per cent of these figures. Busbar supports, wiring end connections will have to be strong enough to withstand the shock of each short circuit, and disconnecting switches must be so designed that short circuits of this magnitude will not blow them open.

The present feeder breakers equipped with definite time limit relays can be set so that they will not trip until the expiration of 2 sec. when the continuous short circuit current would be in the neighborhood of 27,000

amp. if the entire station were operating in parallel on one set of busses. As this is far beyond the guaranteed rupturing capacity of the breakers, it is proposed to use a group system of connections as shown on the single line diagram, Fig. 41.

With the arrangement indicated, all of the breakers connecting to the main 2400-v. busbars will be either like Fig. 5 or Fig. 7 (p. 128, Jan. 15 issue), the latter breakers being needed for current carrying capacity for use with the 12,500-kv.a. unit. The 3000-amp. breaker has a guaranteed rupturing capacity of 150,000 amp. at 2500 v.

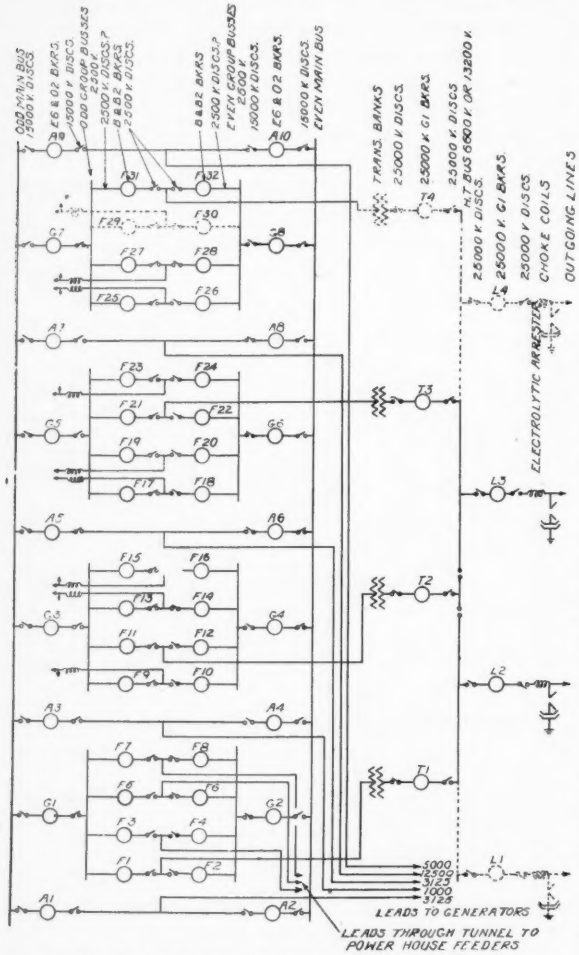


FIG. 41. SINGLE LINE DIAGRAM OF CONNECTIONS

The breakers proposed for the group circuit will be the 2000-amp. breakers like Fig. 5, having a guaranteed rupturing capacity of 74,500 amp. The 2000-amp. breaker for use with the 5000-kv.a. generator will have this same rupturing capacity.

The 1200-amp. breakers, like Fig. 5, proposed for the 3125 and the 1000-kv.a. unit have guaranteed rupturing capacities of 60,000 amp. at 2500 v., this rating being determined principally by the current-carrying capacity of the contacts.

The breaker for use in the circuit of the 1000-kv.a. generator will be like Fig. 5, with the poles specially spaced so that the structure can later by utilized for 3000-amp. breaker if a 12,500-kv.a. generator is substituted for the 1000.

The group circuit breakers will be provided with induction relays set to trip with the minimum time element so that the breakers can open up in approximately ¼ sec., when the station could possibly be delivering six times full load current or about 54,000 amp. if all of the generators were in parallel on the one set of busses at the same time. These group breakers would be operated from current transformers having a ratio of 2000 to 2½ (4000/5) so that they would be capable of being set to trip at any current between 3200 and 6400 amp.

The smaller feeder breakers being provided with relays set for 2-sec. tripping, will open up under ordinary overload at the end of 2 sec. provided the energy flowing into the short circuit does not amount to that required for tripping out the group breakers, namely, 3200 to 6400 amp. If any of the group circuits are normally heavily loaded, current transformers of a higher ratio, namely, 3000 to 2½ (6000/5), can be substituted so as to make the tripping range from 4800 to 9600 amp.

TRANSFORMERS

AS SHOWN on this same diagram, there will be three present banks of transformers, each of which is to be of about 6000 kv.a. capacity stepping up to 6600 or, more probably, 13,200 v. The breakers which it is proposed to furnish for use in the 6600 or 13,200-v. circuit will be the 25,000-v. breakers, like Fig. 9, these having a guaranteed rupturing capacity of 4500 amp. at 15,000 v.; 10,300 amp. at 7500 v.

Assuming the reactance of the transformers as being approximately 4 per cent and the ultimate installation to comprise four 6000-kv.a. banks and the generator capacity being taken as 36,000 kv.a. with 12 per cent reactance, the short circuit conditions on the 6600 or 13,200-v. circuit would be the same as could be delivered by a 36,000-kv.a. generating plant at about 18 per cent reactance. This means an instantaneous short in the neighborhood of eight times full load, a short at the end of ¼ sec. of 4½ times full load, and at the end of 2 sec. 2.8 times full load. As full load may be considered roughly as being 3200 amp. at 6600 v., 1600 amp. at 13,200 v., the breakers will have sufficient rupturing capacity for their contemplated service.

As shown in Fig. 40, Elevation of Switchgear, it is the intention to locate the main 2400-v. busbars with the large breakers in masonry compartments on the second floor of the switch house, while the present smaller solenoid operated breakers will be located on their pipe framework on the lower floor of the switchhouse.

Owing to the short circuit strain to be expected on this system, the present busbar supports used with the installation of small breakers will be replaced by heavier supports and the present disconnecting switches that are without latches will be replaced by switches with latches.

As shown in Fig. 40, the incoming generator leads run below the beams that carry the second floor and will pass through either or both of the circuit breakers and disconnecting switches to the main 2400-v. busses. Disconnecting switches are provided on each side of the breakers for completely isolating a breaker for the purpose of inspection or repairs.

On the main floor directly below the large breakers has been shown the equipment of smaller solenoid operated breakers on their pipe framing. Following out the present arrangement in the generating station, no disconnects are provided between the 2400-v. busses and the small breakers, the idea being that if it is necessary to inspect or repair a breaker, one set of busses can be completely shut down and the disconnecting switches on the line side of the feeders can be opened. Space has been left available so that if desired, disconnecting switches may be utilized on both sides of every small breaker. The line connections from these breakers are run out to the step-up transformers or to the feeder circuit in the manner indicated.

As shown in the plan views, Figs. 38 and 39, there is at present a tunnel running from the generating station to the present transformer house, and it is intended that all of the generator leads shall be run through the tunnel and the circuits to the pump; station service and arc groups will be run back from the switch house to the generating station through this same tunnel. The rest of the 2400-v. feeders will be taken out overhead and the choke coils have been shown suspended from the ceiling with the 2400-v. lightning arresters mounted on the station wall.

In the transformer yard, space has been left to permit withdrawing any transformer without interfering with the switch gear.

Each oil breaker shown in the transformer yard is of the outdoor frame mounted construction with disconnecting switches on each side of each breaker, these disconnecting switches being attached to a framework that can be supported from the ground at intervals.

Current from the high-tension side of the transformers is taken through suitable conductors to disconnecting switches, then through the breaker and other disconnecting switches to the high-tension bus. From this high-tension bus the current passes through disconnecting switches, line breaker and other disconnecting switches to the outgoing feeder circuit. Lightning arresters of the outdoor electrolytic type have been shown for the 13,200-v. circuits. These outdoor 13,200-v. circuits can be carried to the roof of the switch house or to a pole line as preferred.

With the new equipment it is proposed to erect a switchboard gallery either above the present panel board or at the end of the station, this gallery being approximately 10 ft. wide and of sufficient length readily to accommodate the panel board and control desk shown on Fig. 42.

As indicated, the control desk will be of the gallery type so that the station operator standing at the desk will face the generator room and can look underneath the instrument frame and above the desk top to watch the machine which he is controlling.

Back of the operator will be located the panel switchboard controlling the exciters, the field circuits of the a.c. generators, and containing the various relays needed in the different circuits.

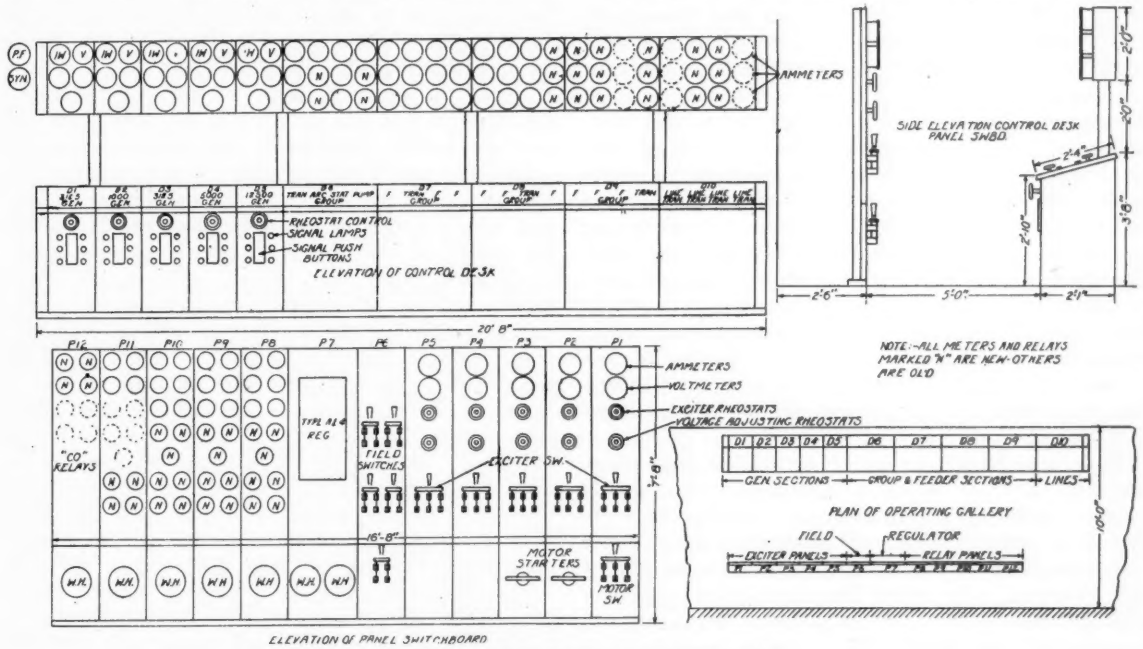


FIG. 42. CONTROL DESK AND PANEL BOARD

The panel switchboard will be of the usual construction with 90-in. panels mounted on angle framework and provided with exciter and field busses running back of suitable panels and with the necessary panel wiring on all panels. Back of the a.c. panels will be located suitable terminals for connecting in testing instruments in the various circuits.

The control desk will be of the usual gallery type with marine finished slate panels, marine finished horizontal slate slabs for the control switches, and steel plates for the front, rear and ends. Suitable ventilation will be provided by means of small grill work directly under the horizontal slate slabs.

The desk will be provided with suitable control and calibrating terminals and a complete miniature bus system will be arranged to show all of the main connections in the plant.

The Frequency Problem in the Steel Industry*

WHAT SHALL BE THE STANDARD FREQUENCY OF THE FUTURE? PAST AND PRESENT TENDENCIES DISCUSSED. BY B. G. LAMME

SOME 15 YR. ago, recognizing the advisability for standardization of certain requirements in connection with their work, the steel mill engineers took up the question of choice of frequency. At the time, all the electric power used by the steel mills was produced in their own plants, and, in many cases, such plants were of relatively large capacity compared with central stations.

At the time, there were only two frequencies in general use in this country, namely, 25 or 60 cycles. The steel mill engineers, therefore, confined themselves to a comparison of these two frequencies, and their fitness for steel mill work in general. Various applications of electricity to steel mills then in use, and in contemplation, were gone into quite fully. At that time there were three conditions of service which required special consideration, namely, (1) the operation of large very low speed induction motors; (2) the transformation from alternating to direct current; and (3) the parallel operation of slow speed gas-engine driven generating sets.

At the time that this study was made, much of the heavier service of the steel mills was contemplated at relatively low speeds with direct connected motors, or with as little gearing as possible on the basis that large, high speed, high power gears would not be satisfactory. As motors up to 6000 hp. nominal rating, with speeds of 75 to 90 r.p.m., were considered necessary in certain applications, it appeared, from all points of view, that for such work 25 cycles was far better than 60, both from the standpoint of the general performance and the first cost.

In transformation to direct current, both synchronous converters (or "rotaries" as they are often called) and motor-generators were recognized as possible methods. With rotaries, 25 cycles offered by far the better proposition, compared with the 60-cycle rotaries of that time; whereas, with motor generators, there was not much difference. With induction motor drive, for motor-generator sets, naturally the lower frequency appeared to offer advantages, while with synchronous motor drive the 60-cycle possibly was better.

The third condition mentioned, namely, parallel operation, is one which concerned, principally, gas engine drives. It was the belief that by using furnace gases with suitable large, low speed, gas engines, the most economical generation of power would be obtained. It was well known, at the time, that, with 25 cycles, parallel operation of alternators, with gas engine drive, was a much easier proposition than with 60 cycles, and even with 25 cycles there were some doubts regarding successful paralleling.

Taking all the various conditions into consideration, the steel mill engineers decided definitely upon 25 cycles as their future standard for generating plants. A standard voltage of 6600 was also decided upon, although this was not considered as of first importance, but practically amounted to setting an upper limit.

This choice of 25 cycles at that time was undoubtedly the correct one, with the knowledge and experience available; it may be stated emphatically that no real mistake was made in this choice of frequency. However, new conditions have arisen in recent years which have changed the complexion of the problem to a certain extent. Fifteen years ago, it was believed, quite generally, that 25 cycles would be the future power frequency of the country on account of its general advantages in generation, transmission, utilization and transformation to direct current.

From the central station standpoint, however, the situation gradually changed. One of the big handicaps of the 60-cycle system was in the greater difficulties in transformation to direct current. However, improvements in the 60-cycle rotary converter, making it a better operating machine, appeared about 15 yr. ago; nevertheless the machine, being of the non-commutating pole type, was of relatively low speed, with many poles, and was unduly complicated and expensive and inefficient. The use of commutating poles on rotaries immediately opened the way to very much higher speeds, so that within a year or two after their real introduction the speeds of both 25 and 60-cycle rotaries began to climb at a rapid rate. Here, however, the 60-cycle rotary had the advantage, for soon the 25-cycle machines reached their limiting minimum number of poles; whereas the 60-cycle machine could go to materially higher speeds before reaching such limits. Consequently, in this race toward higher speeds, the 60-cycle rotary, in the smaller capacities especially, soon outran the 25-cycle, while in larger machines it made such a good showing relatively that it put the 60-cycle generating system nearly on a par with the 25-cycle from the standpoint of transforming to direct current. Here was a big step in favor of 60 cycles.

In the development of induction motors, the tendency also was toward higher speeds and from a third standpoint, namely, power generating units, 60 cycles also soon presented advantages. In the earlier days of the turbo generator, the 25-cycle, two-pole, 1500-r.p.m. unit was favored over the 60-cycle, 6-pole, 1200-r.p.m. of corresponding capacity; however, in the race toward higher speeds, which has occurred in turbo generator practice as well as in other lines of electrical design, the 1200-r.p.m., 6-pole machine was dropped in favor of the 1800-r.p.m., 4-pole machine, thus putting the advantage somewhat in favor of 60 cycles.

In transformer development, in the early days, it looked at first as if 25 cycles had all the advantage, due to the fact that the iron losses were relatively much lower. With improvements in the quality of transformer steel, however, such as the introduction of silicon steel, the advantage began to be on the side of the 60 cycles; and in later development the 60-cycle transformer, as a rule, has proved to be materially smaller, lighter and cheaper than its 25-cycle competitor.

Thus it may be seen from the few indications given above that there were strong reasons for the trend

* Abstract of paper presented before the A. I. E. E. in joint session with A. I. S. E. E., Pittsburgh, Pa., April 16, 1921.

toward 60 cycles for general power generation and distribution. Another consideration must be taken into account, namely: 15 to 20 yr. ago large central stations for general power supply were almost unknown.

In the former days, the steel mill could compete quite favorably with the central station in the cost of power, but with the increased growth of the central power stations and their lower rates for power, the steel mills are naturally strongly tempted toward the purchase of power. Even though the steel power plant may be able to generate power as cheaply as it can be purchased, it still is not, in itself, an attractive investment, as capital is not, as a rule, invested in the steel industry without the expectation of a reasonable return.

The question of purchase of 60-cycle power is dependent, of course, upon many conditions. In the Pittsburgh district, for instance, the total electric power used in the various steel mills may represent the equivalent of a huge power plant in itself. In consequence, if the various mills were to combine their power plants into one general plant, the capacity of such plant and the conditions of operation would probably be such that it could compete quite favorably with any large central station, and in such case 25 cycles could be the frequency.

In considering a single large power plant, however, the Pittsburgh district represents very unusual conditions in that there is a concentration of many huge steel plants within one relatively limited district. A combined steel power plant in the Pittsburgh district would, therefore, represent a very special rather than a general condition and would furnish the solution of the problem for only one general district. In other districts the problem of 60 cycles versus 25 cycles would have to be met.

With this question of purchase of power before them, a number of the steel mills throughout the country which have been planning to increase their power plants are faced with the question of installing an additional plant of 60 cycles instead of 25 cycles; also, with their existing 25-cycle plants, the purchase of additional power at 60 cycles involves numerous problems in the application of such power to the existing equipment. Various suggestions have been made from time to time as to how to handle this situation in its various forms. Probably as good a way as any to look into the problem would be to classify the various methods by which the double frequency situation could be met. These methods may be given as follows, the order in which they are given, however, not representing their importance.

(1) Rebuilding, or obsoleting, existing plant and replacing entirely with 60 cycles.

(2) Conversion of 60-cycle purchased power to 25 cycles by frequency changers and operating in connection with existing plants. This retains the advantage of the existing 25-cycle system, but means, however, considerable losses due to the frequency changers.

(3) Allowing the existing 25-cycle plant to remain in service and installing new generating and motor equipment for 60 cycles. This would allow purchased 60-cycle power to be utilized in connection with the new generating plant. This, however, involves a more or less mixed system throughout the plant.

(4) Retaining the existing 25-cycle plant for those parts of the service where 25 cycles are materially better, and changing other parts to 60 cycles for use on purchased power. This could be continued until the old plant and equipment became obsolete. This would probably mean a mixed system throughout the mills for years to come.

(5) Utilizing the existing plant within certain areas and applying 60-cycle purchased power to extensions and new areas. This involves a double system, but not a general mixture of two systems in the same areas. Eventually if the purchased power proves more satisfactory than the local supply, the latter could gradually be obsoleted. This means, however, that in the new areas the 60-cycle would be applied to slow speed motors as well as all other apparatus.

Looking at the matter broadly, it does not seem advisable to generate two separate frequencies in the local plant. In other words, if 25 cycles is the existing frequency, it is not desirable to put in an additional generating plant at 60 cycles unless such new equipment is to be of greater capacity than that already installed.

It may be said that there is no good general solution to this frequency problem and each case must be handled on its merits, taking the future tendencies and growths into account. In many cases it appears that the large existing 25-cycle local systems should be retained at least until such time as the need for replacement is more obvious than at present. Unless the future service of the mill shows strong indications of going almost entirely to 60 cycles, a mixed generating plant is not to be recommended. In those cases where existing 25-cycle power and purchased 60-cycle power are both to be used, they should at first have their own individual services or areas, as far as possible, to avoid indiscriminate mixing of services throughout the mills, and to avoid frequency changers, with their attendant losses, unless conditions are such as to warrant their use. In general, where both frequencies are liable to be used for some time to come, and there is any real necessity for a tie between the two, then frequency changing becomes a necessity.

In case of a new plant, even where it expects to generate its own power, in general it should be installed at 60 cycles, if located in a 60-cycle district, simply on account of future possibilities. There is no question whatever that future central stations will supply power for general purposes, at 60 cycles, within certain large districts, the trend being too strong to be changed or controlled. In other large districts it will be principally at 25 cycles, as in the territory served by Niagara, for instance. There will be still other cases where both frequencies will be used, simply because the field for 25 cycles is already so large that 60 cycles cannot replace it. In New York City, for instance, 25 cycles is already in use on such a vast scale (1,099,600 kv.a., 25 cycles, and 217,000 kv.a., 60 cycles) that it may be almost a lifetime before the 60-cycle service overtakes it. But the present growth in 25 cycles appears to be limited to existing plants which may never be replaced by 60 cycles. In consequence of this mixed service the ultimate solution of the general supply problem may mean 60 cycles for general purposes, with 25 cycles as an auxiliary supply.

The New Calumet Station

DETAILS REGARDING THE MOST RECENT ADDITION TO THE COMMONWEALTH EDISON CO. SYSTEM DISCUSSED BY ALEX. D. BAILEY

SPEAKING AT a joint meeting of the mechanical engineering section of the Western Society of Engineers with the Chicago section of the A. S. M. E. on April 18, Alex. D. Bailey, superintendent of generating stations of the Commonwealth Edison Co., made public, for the first time, some of the details regarding the new Calumet Station.

This station, destined to be the largest generating station in Chicago, is now in course of construction at 100th St. and the Calumet River, the heart of a rapidly rising industrial center. It will be to the southeast side of Chicago, what the Northwest Station is to the opposite side of the city.

In addition to including most of the principles which time and experience have proved successful in the older stations, a number of new features will be incorporated in the new station.

The ground area covered by this plant will be 43 acres. This large amount of space is necessary because of the coal storage requirements, present-day practice making it essential that 150,000 tons of coal be kept on hand at a station of this type at all times. Ample trackage has been provided for the efficient delivery and handling of this large quantity of coal in the shortest possible time.

General Layout

THE BUILDINGS not only conform to the most modern principles of power plant construction, but have been designed attractively from an architectural point of view as well. The exteriors are to be faced with pressed brick while the interiors will be finished off in white enameled brick and tile. In accordance with present day practice, the boiler room occupies a large percentage of the total building volume, the exact proportion in this case being 65 per cent. This large boiler room space has become necessary in stations of this type, due not only to the decreasing size of the generating units per kilowatt of the capacity but also to the increased height of modern boiler settings and the additional space required for economizers. The turbine room at this station takes up but 15 per cent of the total building volume.

There are five different rooms, enumerated as follows: The boiler room, which includes the coal unloading and handling equipment; the turbine room, the transformer room, and the switch room. The offices will be located above the switch room.

Water for condensing purposes will be taken from the Calumet River through open channels leading to the station. The matter of providing suitable condensing water, however, was not solved as simply as the foregoing statement may seem to indicate because of complications set up by a peculiarity in the flow of the river. This river reverses its flow at times and to overcome the difficulties in operation arising from such a reversal, it was necessary to construct a tunnel, running parallel with the river for some distance through which the condensing water may be taken instead of the channel referred to above.

Two traveling water screens and one fixed screen will insure clean condenser water.

Capacity

THE INITIAL development calls for a 60,000-kw. plant, which will tie in with the present system. The generating equipment for this installation will consist of two 30,000-kw. turbo generators, each unit being served by four boilers, and each unit of four boilers being served by one stack. While the ultimate capacity of the plant as planned at present calls for six units, it is impossible to predict with any degree of accuracy the probable size of the future units. If the history of development in power plant equipment during the past 20 yr. may be used as a basis for prediction, it is entirely probable that the future units will be larger. This has been the company's experience with the older stations and it is not unreasonable to suppose that similar conditions will be met with in the case of the new plant. Indeed, there may be more truth than humor in Mr. Bailey's joking remark that in the case of the Calumet Station, instead of starting near the river and building towards it as was done at Fisk St., they are starting at the river and working away from it so as to be certain of having sufficient room for future expansion.

The Boiler Room

THE BOILERS are of the cross drum, horizontal water-tube type, rated at 1500 hp. each. There will be two chain grate stokers to each boiler, two being necessary on account of the excessive width of the boilers. The combustion space has been made of ample size in order to secure complete combustion of the gases and to eliminate smoke, the distance from the grate to the lower row of tubes being 16 ft. Inclined vertical baffling has been provided in these boilers to secure a greater surface exposed to direct radiation and also to equalize the velocity of the gases through the various passes.

Steam will be generated at a pressure of 350 lb. per sq. in. and will carry 250 deg. of superheat. Under normal conditions, the boilers will be operated at 300 per cent of their rated capacity.

Economizers will receive water from the feed water heaters at a temperature of 175 deg. F. This temperature for incoming water is, of course, considerably higher than theoretical economic considerations dictate, but to overcome corrosion difficulties due to the formation of sulphurous acid on the economizer tubes at low temperatures, the high water temperature is a physical or rather a financial necessity. The flue gases leaving the boiler at a temperature of 650 deg. are cooled to about 300 deg. in passing through the economizers. In this connection, it may be of interest to mention the air heater, the future installation of which Mr. Bailey said was being considered. This air heater would consist of a series of alternate plates between which flue gases leaving the economizer would pass in one direction while incoming air to the furnaces would pass in

the opposite direction. The final flue gas temperature would in this manner be reduced to about 100 deg., while the incoming air to the furnaces would be heated to 200 deg. Theoretically, such a heater will increase the overall economy, but it must be pointed out that while in operation the device would virtually be a condenser for sulphurous acid and the consequent corrosion troubles may render its successful adoption impracticable.

Without considering the air heater, it is aimed to secure an overall boiler efficiency of 83 per cent, this figure including the gain in efficiency due to the economizers.

Another feature of interest is the revolving coal breaker which will be installed instead of the usual crushers. This consists of a large revolving cylinder, set horizontally and slightly inclined, the inside of which is fitted with projecting shelves. Coal is delivered into this cylinder at one end, and due to the revolving motion is lifted to the top and then dropped to the bottom, thus breaking it. Holes in the cylinder allow coal of a sufficiently small size to pass through while all unbreakable material is discharged at the opposite end of the cylinder. In operation, it is surprising to note the large quantity of unbreakable material, such as bolts, car springs, pieces of steel, etc., that is thus sifted out, and no great amount of imagination is necessary to account for broken rollers in crushers and other crusher troubles when the latter are used. It is hoped that by the use of this revolving breaker many former crusher difficulties will be eliminated.

The stacks will be self supporting, steel, 174 ft. above the grates and 16 ft. in diameter. These stacks are comparatively small, as practically all draft requirements are met by the forced and induced draft fans.

Auxiliary Equipment

Steam from the boilers will pass through a receiver on its way to the main turbines, a feature which is more or less new in the practice of this company.

The joints in the 18-in. headers carrying the steam to the turbines will be of a type which has been used for some time in the existing stations of the company. This is a combination bolted and welded joint, designed in such a manner as to relieve the electrically welded portion of any strain, the latter being taken care of by bolts passing through the flanges. The object of the welding is merely to overcome trouble due to leaks caused by unevenness in the faces of the pipe ends. This type of joint has been in use for years at the Fisk and Quarry St. Stations without showing the slightest sign of leakage.

Feed water will be heated by a combination of two closed heaters and one open type. Make-up water is to be supplied by evaporators, suitable precautions being taken, however, to deaerate the distilled water thus obtained before delivery to the boilers, in order to prevent corrosion due to the use of too pure water.

Practically all of the auxiliaries will be motor driven. Only enough auxiliaries will be steam driven, as may be necessary to maintain a heat balance.

Four centrifugal boiler feed pumps will be provided, three being motor driven and one turbine driven.

Generating Equipment

As stated previously, each of the two initial turbo generating units will be rated at 30,000 kw. One of these will be a single cylinder machine, while the other will be a tandem compound unit. Steam will be supplied at 350 lb. pressure and the surface condensers will maintain a vacuum of 29 in.

Equipment is to be installed on the condensers which will allow of their being cleaned while in operation. This cleaning equipment consists essentially of a number of ball socket nozzles fitted into the water head of the condenser. By connecting a hose to these nozzles, water at a pressure of 250 lb. per sq. in. may be directed against the tube sheet, thus removing the slime and other sewage which invariably collects in the condenser. This cleaning equipment not only saves considerable expense due to the shutting down large units for the mere purpose of cleaning the condenser, but also does away with the disagreeable task of having to do this cleaning by hand. Mr. Bailey stated that the cost for excess coal alone due to carrying the load on less efficient equipment when cleaning the condenser by hand amounts to about $1000 a day.

Current will be generated at 12,000 v. and then stepped up to 33,000 v. so as to tie in with the existing system. All auxiliary motors under 50 hp. will be 220 v. d.c. while all motors over 50 hp. will be 2300 v. 60 cycle a.c.

The bus system will possess a novel feature in that the same phases of the duplicate sets of main busses will be grouped together. That is, instead of grouping the phases A, B and C of one bus on one side of the room and the A, B and C phase of the other bus on the other side, the A phases of each bus will be grouped together on one side, the two B phases in the middle and the two C phases on the other side. This arrangement precludes any possibility of short circuit between the adjacent phases of one bus.

The 33,000-v. underground cable which will tie the new station to the present generating system will have all three phases in one cable and when operating at the above voltage will be the highest voltage underground cable used in America.

U. S. Civil Service Commission announces examinations (receipt of applications to close May 24) for junior mechanical engineer—$1500 to $1800, mechanical engineer (internal combustion)—$3000, and mechanical engineer (designing)—$3000, to fill vacancies under the National Advisory Committee for Aeronautics, for duty at Langley Field, Va., at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries. Apply for Form 2118, stating examination title.

There was a beautiful lawn and flower bed in front of the office building. Horatio was employed at the power house as a general handyman. One of his colored brethren accosted him, saying:

"Well, Horatio, how's ebberything wid de power plant? I'se trust dey am doin' fine."

"Well, not zackly. I'se notices dat de gernamiums ain't lookin' near so well as de oleanders."

Unsatisfactory Heating Systems

CAUSES OF TROUBLE AND REMEDIES. BY H. A. JAHNKE

FREQUENTLY we find that a heating system in a manufacturing plant or other building does not give satisfactory results, due at times to the improper installation of the pipes, such as the feed or return mains or due to a defect occurring in the pipe system after it has been installed.

It is the writer's intention to show why some heating systems do not give good results.

FAULTY PRESSURE GAGE

IN ONE INSTANCE, where the steam pressure was reduced from 120 to 10 lb. for use on the heating system it was noticed for some time that there was not sufficient heat, although the pipes and radiators were warm and the pressure on the gage at the reducing valve on the low pressure side showed the required pressure, as usual.

At first it was thought that the small traps at the outlet of some of the radiators and pipe coils did not work properly. On examination, they were found in good working condition, and the return pipes were clear. In thinking the matter over I came to the conclusion that there was not sufficient pressure to heat all the radiators and coils on the system. When about to adjust the regulating valve to a higher pressure, I found that the hand on the gage did not move. After the gage was replaced by another and after turning the steam on I found that there were only about 3 to 4 lb. of pressure on the heating system in place of 10 lb., as the gage showed. Upon adjusting the reducing valve to 10 lb. pressure on heating system, there was not the slightest trouble in getting sufficient heat in the plant.

In another instance, it was found that a pressure regulator would regulate as it should during the day time, when the initial pressure was at the high working pressure, but at night when a lower pressure was carried on the boilers, the regulator valve would either hang up or close entirely. If the valve closed entirely it would not open again after the pressure was raised to the regular working point, and the valve had to be opened by raising the weight lever. The valve was taken apart a number of times, but nothing found wrong. One morning after the valve had closed entirely again during the night, when about to open the valve by moving the weight lever, I noticed that it opened much harder than before. I then disconnected the regulator from the line to give it a thorough examination, when I found that the dashpot on the valve was the cause of the trouble. The piston in the dashpot had worn a shoulder in the cylinder in such a way that when the pressure in the boilers went very low, so as to bring the dashpot piston into a certain position, the piston would stick, not allowing the regulator valve to open until it was forced open by hand. After removing the shoulder in the dashpot cylinder, there was no further trouble.

WRONG RETURN CONNECTIONS

AN INEXPERIENCED pipe fitter may cause much trouble at times by arranging the inlet and outlet to radiators in such a manner that they cause water hammer or give trouble in some other way.

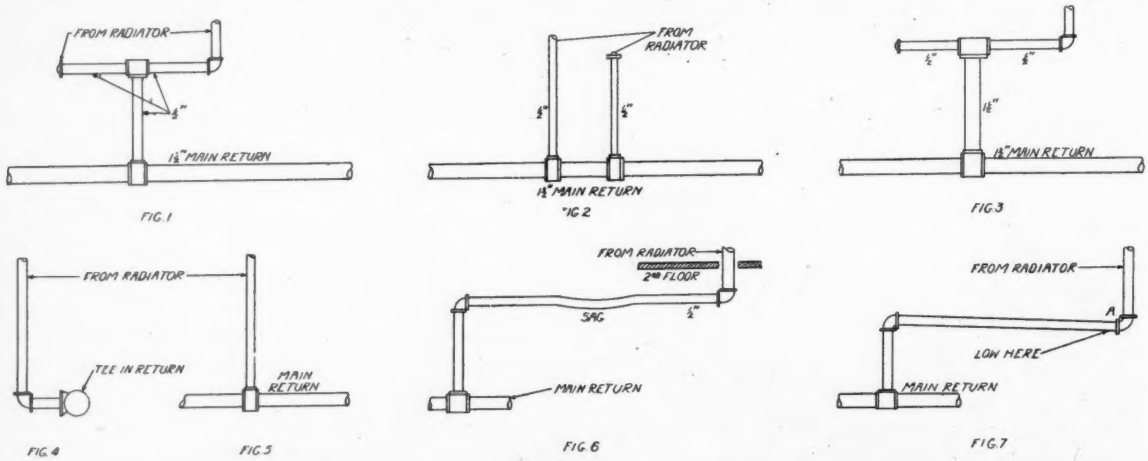


FIG. 1. THESE CONNECTIONS CAUSED WATER HAMMER. FIG. 2. REARRANGMENT OF PIPING SHOWN IN FIG. 1 TO ELIMINATE WATER HAMMER. FIG. 3. ANOTHER METHOD OF OVERCOMING DIFFICULTY CAUSED BY PIPING IN FIG. 1. FIG. 4. IMPROPER METHOD OF CONNECTING RETURNS TO RETURN MAIN. FIG. 5. PROPER METHOD OF CONNECTING RETURN MAIN. FIG. 6. SAG IN PIPE CAUSES WATER HAMMER. FIG. 7. RETURN PIPE PITCHED THE WRONG WAY CAUSES NOISE.

Figure 1 shows where the two outlets from two large radiators were connected into a ½-in. tee. From this tee a ½-in. pipe led into the 1½-in. main return. There always was more or less water hammer in these connections between the ½-in. pipe and the two radiators and nobody seemed to know where the trouble lay. My attention was called to the matter. In studying the layout for a time, I came to the conclusion that the connections were wrong, as it was my idea that whenever the two traps on the radiators discharged at the same time there would be water hammer between the ½-in. tee and the 2½-in. pipes from the radiator lead-

ing into it, as the ½-in. pipe leading from the tee into the tee in the 1½-in. main return pipe could not take care of all the water when both traps discharged at the same time. Then should more or less steam be discharged from one of the traps, there would occur a knocking noise in the pipes. I changed the layout in such way that the condensation from each radiator was discharged individually as shown in Fig. 2, after which there was no more noise.

If it is absolutely necessary to arrange the returns from two radiators as shown in Fig. 1, the vertical pipe between the tee in the 1½-in. main return should be 1½-in. also, then using a ½ by ½ by 1½-in. tee where the two ½-in. pipes from the two radiators connected into as shown in Fig. 3.

Side vs. Top Connection in the Main Return

Frequently some pipe fitter connects the outlets from the radiators into the side of the main return pipe as shown in Fig. 4. In this case, should there be a large number of radiators connected to the return pipe there will be more or less noise in the pipes, due to water hammer, which in turn is due to the fact that, when most of the traps on the radiators discharge at the same time, the main return pipe will be full of water of condensation; then should a little more steam escape by one of the traps there will be more or less noise in some of the pipes until the return pipe is partly or entirely empty again.

It is better to connect the outlet from each radiator or coil into the top of the return pipe as shown in Fig. 5. In this way the ½-in. pipe between the radiator trap is not apt to be filled with water from main return pipe to the trap, as is liable to occur where the pipe enters the side of the pipe as in Fig. 4.

Noise in a return pipe at times is caused by the pipe being sagged, as shown in Fig. 6. This sag forms a pocket in which water of condensation collects, and whenever the radiator trap discharges steam, noise will occur in the pipe. The remedy here is to provide more support for the pipe so no pocket will form.

Return Pipe Pitches Wrong Way

Pipe fitters often make the mistake of pitching a return pipe the wrong way, as shown in Fig. 7, which is due to carelessness or to some cause unknown to the man doing the work. This also will cause more or less noise in the return pipe, as water will collect at the lower point. Either one of the vertical pipes should be shortened so the pipe will pitch toward the main return.

Frequently a careless pipe fitter will cut a piece of pipe either too short or too long; then in connecting the pipe to the trap or radiator, the joints are forced together, placing a strain on the pipe at some point which either forms a pocket in the pipe or the pipe may pitch the wrong way, thereby forming a pocket, resulting in a noisy return pipe.

Pipe Covering Will Sag Pipe

In some instances a heating system will operate satisfactorily in every way, but shortly after the pipes are covered noise occurs in some of the return and feed pipes. The writer had a case of this kind some time ago where the system operated satisfactorily until all the pipes were covered. This was a puzzle to me for a long time, but I kept on looking for the cause. One day I happened to think that perhaps the covering had sagged some of the pipe, thereby forming a pocket.

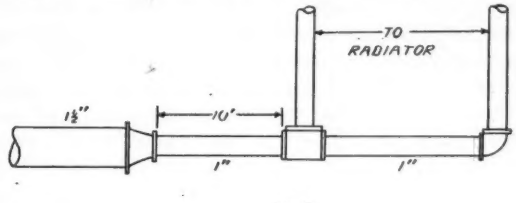


FIG. 8

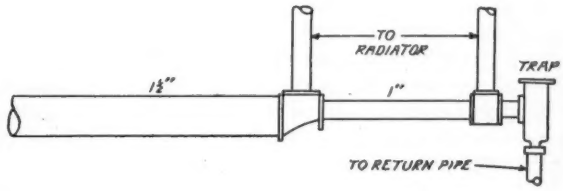


FIG. 9

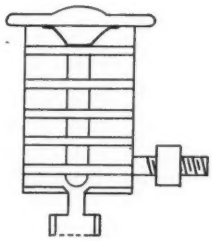


FIG. 10

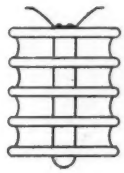


FIG. 12

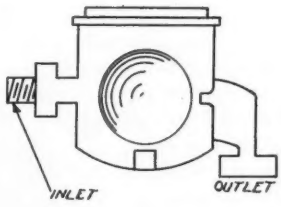


FIG. 11

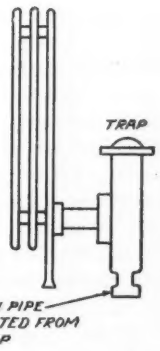


FIG. 13

FIG. 8. SMALL RADIATOR FEED PIPE RESULTS IN LOW TEMPERATURES. FIG. 9. METHOD OF CORRECTING CONDITIONS CAUSED BY CONNECTIONS OF FIG. 8. FIG. 10. RADIATOR TRAP WHICH MAY BE RENDERED INOPERATIVE BY DIRT OR SCALE. FIG. 11. BALL TYPE OF RADIATOR TRAP. FIG. 12. EXPANDING MEMBER OF TRAP SHOWN IN FIG. 10. FIG. 13. METHOD OF TESTING RADIATOR TRAPS.

After examining the pipes, I found this to be the trouble; some of the long lengths of ½-in. return pipes from the radiator and coils had sagged considerably, due to the extra weight of the covering. As these pipes were near the ceiling, this was not noticed while looking at them from the floor.

All the covering was removed from the pipes that sagged and more supports were installed. The covering was then replaced and the trouble was found to have disappeared.

Larger Pipe Was Necessary

The end radiator on a long line of pipe where low-pressure was used on the heating system would not give sufficient heat when all radiators were turned on during very cold weather. One day in examining the feed and return pipe, I found that the last two radiators on the steam line were fed by a 1-in. pipe as shown in Fig. 8. In thinking the matter over, I came to the conclusion that a large pipe would remedy the trouble, so the pipe was changed to that shown in Fig. 9, where the 1½-in. pipe was continued to the second last radiator on the line. After this the last radiator received more steam, hence gave more heat. There also was much noise in the pipe between the two radiators whenever the last radiator was shut off for any length of time. To remedy this trouble, I placed a tee instead of the elbow leading to the last radiator, then attached a small radiator trap at the tee as illustrated. This kept the line free of condensation whether the last radiator was turned on or not.

Some Radiator Trap Troubles

Before connecting a trap to a radiator or coil, steam should be blown through them to remove all loose scale and dirt that may be lodging in them, especially in new radiators and coils, otherwise there will be a leaky or ruined trap in a short time.

I have made it a practice to strike each section of a radiator a few light blows with a hammer before placing it in position, to loosen all scale and rust in the sections, then tipping the radiator on one end and striking the bottom a few blows; in this way all loose scale and dirt drops out through the pipe opening, so that only the fine dust remains in the radiator. After this the radiator is connected to the steam line. Should there be steam handy, the radiator and all pipe connections are thoroughly blown out so as to remove all fine dust and scale. After connecting the trap to the radiator, the bonnet and expanding member of the trap are removed and steam is blown through the radiator and trap to make sure that no foreign matter remains. The expanding member is then thoroughly emptied off and replaced in the trap and the bonnet screwed on. In this way I am sure there is no danger of ruining the trap or any of its parts.

Should there be no steam on the line when attaching traps to radiators or coils, the traps are blown out at the time when it is necessary to turn steam into the radiators by removing the bonnet and expanding member.

I decided to follow this practice after having had much trouble with a number of small radiator traps of the type as shown in Fig. 10. When installing a number of new radiators and after blowing steam through the radiators to remove all dirt, the traps were attached and radiators placed in service and all seemed to be in good working order; but a few days later a number of the traps leaked badly. In taking these traps and grit which caused it to stick so it would not expand, thus preventing it from closing the trap. By blowing steam through the radiators and connections before attaching the trap, all grit and dirt may be removed; but when connecting the trap more or less pipe joint cement (white lead, graphite, oil, etc.) which is used at the trap joints, will work into the trap and stick to the interior of it for a long time and prevent the trap from closing tight and cause leakage.

I know this to be a fact, as one time I connected a small trap of the ball type, as shown in Fig. 11, to a radiator which had been in use for a long time. A few days after the trap was attached, it leaked badly. In taking it apart I found that the ball was covered with dirt and grit to such an extent that it would not close the trap tight. Most of this foreign matter came from the pipe joint cement used at the joints.

For this reason I remove the bonnet and expanding member, or whatever may be necessary, depending on the type of trap, so it is possible to blow steam through the trap. This can not be done without removing the expanding member.

Renewing Expanding Members in Traps

In many instances I have noticed that when traps of the type shown in Fig. 10 leak badly, they are replaced by an entire new trap. This is wasting good money, as it is not necessary to throw the entire trap into the scrap heap. All that is necessary, should the trap leak, is to unscrew the bonnet; then if you find that the expanding member, as shown in Fig. 2, is broken or in bad condition, all that is necessary is to renew this part and the trap is as good as ever.

In examining a trap that leaked badly I found that parts of the expanding member were broken. As there was not the time to remove the entire trap, I took the expanding member out of a new trap and placed it in the one that leaked, after which the trap worked as well as when new.

Traps Should Be Inspected Frequently

It is advisable to inspect small radiators and heating coil traps frequently to see in what condition they are as it is not seldom that one or more of the traps in the heating system may leak and waste much steam. To show how necessary this is, I shall relate a few instances.

In one case the trap on one of our radiators would let steam blow by at times and then close tight again after the next discharge of the water. At the first opportunity I removed the bonnet from the trap to find what was wrong and noticed a piece of hay wire about ½ in. long in the trap. When this wire was removed, the trap trouble disappeared. I suppose this piece of wire kept on moving around in the trap, sometimes getting in such position that it lay over the trap seat, hence the trap would leak until the wire had moved off the seat.

This wire must have been in the radiator when it was installed and in course of time had found its way into the trap.

How Low Pressure Traps Are Ruined

In plants where the pressure going to the heating system is reduced from a high to a low pressure by a

reducing valve, the radiator or steam coils are usually equipped with low-pressure traps. In a case of this kind, the reducing valve must be watched closely so the pressure does not run up on the heating system, otherwise the low-pressure traps will be ruined in a short time. I had this happen to me at one time, where the pressure was reduced from 110 lb. to 7 lb. One day I noticed that a number of the radiator and steam coil traps leaked badly. In examining them, I found that the expanding member would not close, and I knew at once that the expanding member was ruined due to a higher pressure on the heating system than the traps were made for. Looking at the pressure gage, I found there was about 25 lb. on the heating system in place of 7 lb. as there should have been. After this experience, I always kept a close watch on the reducing valve gage so the pressure would not go much higher than 7 lb.

Why Radiator and Steam Coil Traps Should Always Be in Good Working Order

To show what steam radiator or steam coil traps that leak may waste, I relate the following. In a plant where the steam pressure is reduced from a high to a low pressure to the heating system, the fires are banked under the boilers at night and the steam is left on the heating system all night. For some time it was noticed that the steam pressure was much lower, mornings, than it usually was, and was much lower each succeeding morning. In looking over the heating system, it was found that most of the traps at the radiators leaked badly. After these traps were put in working order again, the steam pressure in the boiler, mornings, was at the same points as it was formerly. In this case the condensation from the heating system was returned to the boilers by means of traps, so there was not much loss of water, as would have been the case had the condensation been going to waste. The waste in this case was due to the pressure going down very low during the night, requiring so much more fuel the next morning to raise the pressure to the working point again, and this last was due to the traps leaking; hence they always should be in good working order.

Testing Radiator and Coil Traps

Radiator and steam coil traps should be tested frequently to see that they are in good working order. My way of doing this is to shut off the steam on the radiator or coil. After disconnecting the trap at the union next to the radiator the trap is disconnected from the return pipe and replaced on the radiator as shown in Fig. 13. Steam is then turned into the radiator or coil, whereupon I am able to tell whether the trap is in good working order or not. To catch the condensation, a pail is held under the trap.

Where it is impossible to hold a pail under the trap to catch the condensation during the testing operation, the trap may be removed entirely and attached to some pipe in the boiler room where there is low pressure.

Feed-Water Heaters and Ammonia Receivers

The Necessity of Keeping Proper Level in Liquid Receiver Is Well Illustrated by Comparing Refrigerating System with Feed Heater. By A. G. Solomon

MANY engineers do not like to walk into the manager's office and tell him that the system is short of ammonia. The engineer seems to think that asking for a drum of ammonia is an acknowledgment of his failure to operate the plant properly. He looks on the asking for ammonia in about the same manner as he does his being called upon to confess that he has caused expense through his neglect or carelessness.

Ammonia must be circulated to take up heat just as truly as fuel must be burned to make steam. When the coal pile begins to look small or the supply of fuel oil gets low, it is the most natural and simple thing to put in an order for more fuel. The fuel is needed and there is no question on the subject. To make the needed amount of steam to operate the plant, a certain amount of fuel must be burned.

A proper amount of pure ammonia in the system is just as necessary as is the proper amount of fuel in the furnaces.

There are few engineers or firemen who have not been caused a great deal of trouble and worry by the varying water level in the boiler feed-water heater.

All heaters are, or should be, provided with a water glass to show the amount of water in the heater. A float and regulating valve are also provided to make it possible to control the water level when the speed of the feed pump is changed.

When the float and valve do not operate properly, the water level cannot be maintained at the desired point and troublesome operation and loss in economy result. A varying water level means changing the temperature of the feed water while close economy demands a steady temperature and a steady feed of water into the boilers.

There are plants trying to continue operating with unreliable and therefore useless regulating valves in the water line to the feed-water heater. At times the heater fills, until the water and steam can be heard meeting in the exhaust line. This hammering is the notice that the engineer receives telling him that it is time to shut off on the water going into the heater. He gives this notice consideration and makes a guess as to how much he should close the hand regulated valve.

In a short time, notice number two is received in the form of a boiler feed pump running away, owing to its losing suction because of the fact that the feed-water heater is empty.

The engineer makes another guess at the proper amount of opening for the water valve and the boiler gets water once more. This guess work is not only troublesome and dangerous, but it is very wasteful. Any engineer knows that more fuel is required when operating in this manner than if the water level in the heater were held at a steady height. Such a plant can be kept going by close watching, but that is about all that can be said for it.

Consider a case so extreme as to be impossible. Just imagine an engineer attempting to operate a battery

of boilers that depended, for their entire water supply, on a feed-water heater in which the water level was carried so low that it just covered the suction line to the feed pump once in a while and then for only a short time. Just try to imagine this battery of boilers trying to carry an overload and the fireman crowding the fires to their limit, and at the same time picture the boiler feed pump being supplied with water from an empty heater.

You will rightly say that it cannot be done and that no engineer would attempt such an impossible thing. The utter impossibility of the undertaking is so evident that no engineer would try it. And yet how many engineers are there who are really trying to do exactly the same thing, not in the boiler room with the boilers, pumps, heaters, fire and water, but in the refrigerating plant?

The purpose of this picture is to emphasize the most important thing to be considered in the operation of a refrigerating system.

Trying to make ice while the system is short of ammonia is the direct cause of more loss than all other reasons for failure to produce full capacity.

The cooling of cold storage rooms and the making of ice is just as simple a process as the generating of steam in the boiler room.

In the refrigerating system, liquid ammonia is admitted to the evaporating coils where the heat that causes evaporation is applied. To take up heat from the produce to be cooled or from the water that is to become ice, ammonia must enter the coils in the liquid state. As this is true, the supply of liquid must be sufficient to meet the demand.

Little heat can be taken up by gas that has had its latent heat abstracted. The ammonia is liquefied in the condenser and flows into the liquid ammonia receiver, which is the supply tank in just the same way that the feed-water heater is the supply tank for the water that is required in the boilers.

The evaporating coils are the boilers of the ammonia system. The heat surrounding the evaporating coils is the same to the ammonia system as the fire and heat in the furnace and the tubes is to the steam boiler.

We have just seen how impossible it is to operate a boiler without having a positive water supply. Why is it that an engineer will attempt to operate an ammonia system when he knows that there is an insufficient supply of ammonia to feed the coils properly?

All ammonia liquid receivers should be provided with a gage glass to show the liquid level; and this glass should be watched just as closely as the water glasses on the boilers and the feed-water heater.

When the water drops out of sight in the glass on the boiler, the engineer gets busy at once. He does not necessarily fear an explosion or even the blowing of a fusible plug, but he knows that there must be water in the boilers and he wants to see it in plain sight.

When the water is low in the boilers the pump is speeded up and more fuel is used to hold the steam pressure while the water is gaining. This is waste of fuel.

When the liquid is out of sight in the glass on the liquid ammonia receiver, the compressor is speeded up in a useless attempt to hold the temperature. This increase in speed is waste of fuel, and is also hard on the machine and will mean an addition to the cost of upkeep.

The liquid ammonia receiver must be located in a place where the engineer can watch the liquid level as shown in the gage glass. When ammonia condensers are located on the roof or on a condenser tower, the receiver should be placed in the engine room. Any benefit gained by having the receiver in a cool place will be more than offset by the loss which will result if the liquid level cannot be watched.

The amount of ammonia in the system must be such that the glass on the receiver shows at least half full when the necessary amount of ammonia is out in the evaporating coils absorbing heat. When some of the coils are shut off, the liquid will rise in the receiver. Do not worry about the receiver becoming too full because the condenser will take care of all that the receiver will not hold.

At all times the loss of ammonia through leakage must be prevented. There is no excuse for ammonia leakage at any point in the system. Some engineers seem to believe that it is impossible to prevent all leakage, but it can be done. The true proof of this is the fact that there are hundreds of plants operating day and night throughout the entire year where the faintest smell of ammonia is practically unknown.

When all leaks are known to be stopped, the loss of ammonia is very small and the only additional ammonia needed is that which will take the place of what is lost through decomposition caused by oil, air, and moisture in the system. The loss through decomposition can be kept low by careful operation and watchfulness and by the continuous use of a reliable ammonia purifier. When the charge in the system is insufficient, greater compressor speed, high discharge pressure and temperature, and low suction pressure are called for and the loss through decomposition is greatly increased.

After the liquid level that is to be carried has been decided on, the glass on the receiver should be marked with a narrow strip of adhesive tape or a mark made with paint. Another marker should be attached to the glass so that it can be moved up and down. A narrow piece of red gasket rubber, sewed around the glass, makes a very good movable marker.

Now that we have a full charge of ammonia in the system and the glass on the liquid receiver marked, we are ready to begin properly to operate the plant.

We will consider a plant where ice only is made and where shell type brine coolers are used. The back pressure will be about 18 lb., which will give an evaporating moisture of about 3 deg. above zero. Such pressure and temperature of the ammonia allows the brine temperature to be held at about 14 deg., and it should be held as nearly constant as possible. The number of blocks of ice pulled per hour must be regulated by the brine temperature. Loss in capacity will result if the ice pulling is done in an irregular way.

Carry the ammonia level in the shell coolers at the height that proves to give the best results. As a rule, the coolers are held about two-thirds full of liquid; but under some conditions this level will vary.

Now, if we will watch the entire system closely and pay particular attention to the speed of the compressor, condenser and back pressure, temperature and amount of water going on and off the ammonia condensers, temperature of the water entering the distilled water forecooler and the temperature of the water entering the ice cans, temperature of the brine in the ice tank and the speed of the circulation in the tank, we will find that the system can be so well balanced that any changing condition will be noticed quickly, and the best and most reliable telltale signal will be the liquid ammonia level in the receiver.

While conditions remain constant, the liquid level will vary so little that it can scarcely be noticed. Any change in temperature or amount of circulating water will cause a change in the liquid level in the receiver. Change of the temperature of the brine or change of the speed of the brine agitator will affect the liquid level.

By close observation, it will soon be noticed that by holding the liquid level at a certain point all other parts of the system will operate properly.

To make this more clear: If the circulation of the brine through the tubes of the brine coolers slows down or stops, the ammonia will not evaporate at its regular rate and the coolers will fill. This will lower the liquid level in the receiver. Or if ammonia stores, or becomes gas bound in one or more stands of the condensers, the liquid level will fall in the receiver. If one or more of the expansion valves become blocked with a bit of scale or a particle of oil, the liquid will rise. It will also rise if the ammonia condensers are furnished with a more than usual amount of cold circulating water.

The movable marker is used when some changing condition causes the liquid level to leave the stationary mark. When the engineer sees the liquid at a low or high mark in the glass the movable marker is set at that level and the cause of the change is looked for. Some reason for the changed level will be found, normal conditions will be restored and the liquid will assume its regular level.

There is no part of any kind of a plant that demands more constant attention than does the refrigerating system.

Changes mean loss, and if operating conditions are to be kept constant the liquid ammonia receiver must receive close attention.

In plants where cold storage rooms are operated on the direct expansion system and all the coils are not in continuous use, the charge of ammonia must be large enough so that there is liquid showing in the glass of the receiver at such times just as when all the coils are in use. The engineer must use careful judgment and not carry a heavier charge than is necessary but must still have enough to meet all demands.

In some cold storage plants, several rooms will be empty and allowed to become warm for perhaps weeks at a time. Then word is received that these rooms must be made ready on very short notice. Warm rooms will take a great deal of ammonia until the temperature is lowered to a point about the same as that of the other rooms.

In a case of this kind, the engineer must be careful and not attempt to handle all the hot coils too quickly. Coils that have been shut off for some time are filled with ammonia gas in a highly superheated state. This superheated gas must be taken from the coils by the compressor at a rate that will not throw the rest of the system out of balance.

Turn on one coil at a time and wait long enough for that coil to become cool before turning on another one. If the liquid level falls so low in the receiver that there is any chance of gas entering the liquid line, shut off all the cold rooms for a while if that is necessary to keep enough liquid to supply the hot coils. The pumping down of the coils that have an accumulation of heavy frost on them will do them good, as it will clear them of any ammonia that may be lying sluggish and dead.

After the warm rooms have been lowered in temperature and the coils are frosted, the amount of liquid required will not be so great, conditions will become normal and the liquid level will again become constant. During the time that the extra rooms are in use, the liquid level will remain at a point lower than before. This is a case where the movable marker is used.

Ice cream plants are often run in connection with ice plants and where such is the case the liquid receiver requires extra close attention, as the demand on the ammonia is not constant. The stationary marker will be the indicator for the liquid level during the time when the load is normal. This will be at times when the ice cream freezers and milk coolers are not in operation. The ice tanks and the ice cream hardening rooms can be called the regular or constant load.

The stationary marker must be set high enough to allow for plenty of liquid to show in the glass during what we may term the peak load.

If the plant is out of proportion according to its different parts: that is, the compressor, ice tanks and ice cream capacities, there is bound to be some sacrifice at some points at times. As a rule, the amount of ice pulled is cut down during the time that the ice cream freezers are in operation. This may have to be done, but the engineer should be positive that the sacrifice is absolutely necessary.

Estimate the amount of refrigeration required to handle the given amount of cream and begin an investigation at once if this capacity does not do what it should.

The ice cream hardening room must be watched closely, for, with the low temperature required, a large amount of ammonia will lie out in the coils.

Some quick and positive defrosting means must be provided for such coils or shell coolers as are not equipped with continuous defrosting systems.

An excellent demonstration of the need of defrosting can be had by placing the movable marker at the liquid level while the ice cream hardening rooms are hard to hold and the coils are heavily frosted. Then defrost the coils and notice where the liquid level goes. It has about the same effect as the introduction of one or two new drums of ammonia.

Keep a full charge of ammonia in the system if results are to be expected and watch the glass on the ammonia receiver just as closely as you do the water glasses on the feed-water heater and the boilers. It is every bit as important.

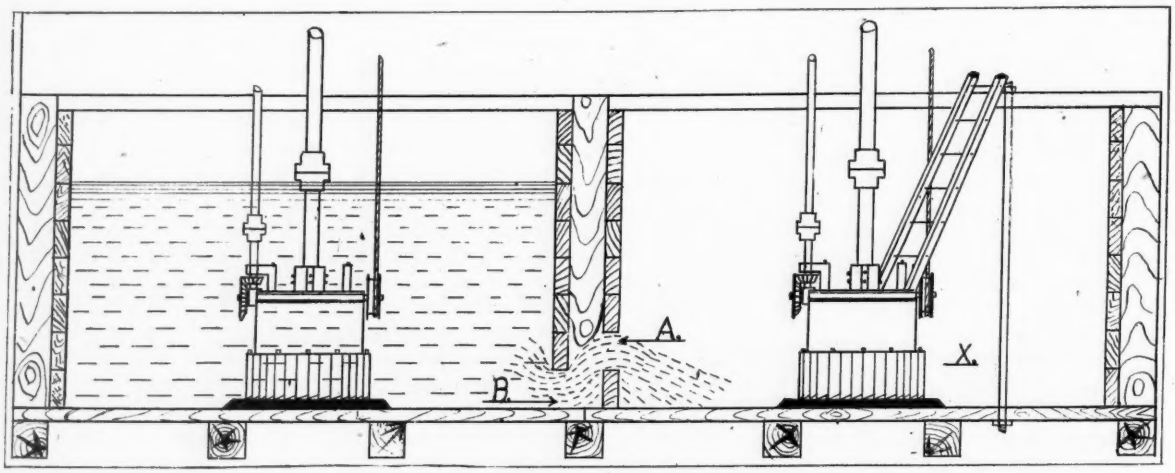
Foresight

THE REMARK is often heard that the use of a little foresight occasionally would prevent a lot of trouble and inconvenience.

The following incident well illustrates the fact, and what came near being a serious accident could have been prevented had the one who was to blame used a little foresight, or reasoning power, and inquired into the why and wherefore as to the condition of things as he found them.

But as it turned out no harm was done and it proved a good lesson to all concerned.

Two men were about to commence work on a water-wheel, repairing the hoisting gear. The wheel was of the vertical type, one of a pair geared to the same jack-shaft. The other wheel was in an adjoining flume with a partition of 12 by 12-in. timber planked up with 3-in. plank on both sides midway between the two wheels.



BREAK BETWEEN FLUMES

It had been customary when working on either wheel to shut the water out of the flume in which was the wheel to be repaired, leaving the other flume full, which was done in this case. The men had been in the flume but a short time; one of them was standing on the bottom of the flume, leaning over, cleaning out the buckets of the wheel; the other was on top of the wheel case or dome preparing to follow the first, when something gave way and the water came in with a rush and knocked the one who was standing on the bottom of the flume off his feet, rolled him over and over and slammed him up against the wheel casing; although somewhat dazed, he had presence of mind enough to grasp an iron rod which ran up alongside of the wheel and pulled himself to an upright position (referring to the sketch, X is the point where the man was standing), the water meanwhile pouring in at such a rate that it was up around his waist by the time he was on his feet. The man who was on top of the wheel reached down and grasped other man's hand and helped him to the top of the wheel. The water was washing around their legs by the time they got straightened up and ready to leave the flume, but as it had more surface to fill and was fast reaching its own level, it wasn't rising so fast. As they had put a ladder down through a trap to the top of the wheel before commencing work, it was only a short time before both were out.

The fellow who had taken the involuntary bath was somewhat chilled, as it was late November and the water cold, and generally shaken up, but without assistance from his mate he might not have succeeded in getting out as well as he did. Of course, he went home and did not show up again for the rest of the day. The other man continued work and with the assistance of the foreman sought to ascertain the cause of the accident.

They shut the water out of the adjoining flume, then went down into the one where the accident happened and found a plank had loosened up and the pressure of the water had pushed it in, leaving an opening 8 in. wide the whole length of the flume for the water to pour in.

Referring to the sketch, A is where the plank was pushed in. They then sought to find where the water was coming from and on going down into the adjoin-

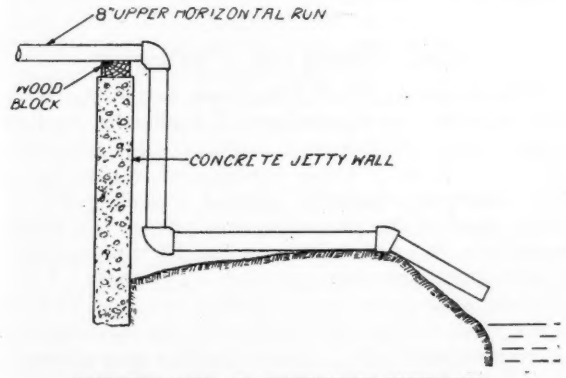
ing flume found a plank off on that side and missing, as shown by B in the sketch. That accounted for the plank being pushed off on the opposite side, as there was nothing to hold the pressure of the water except a few spikes through the plank to hold it in place.

It was then recalled that a short time in the past, the last time work was done in the flume, one of the workmen found a plank lying down on the bottom of the flume and instead of looking around to see where it came from or inquiring why it was there, threw it out of doors. That, of course, accounted for the accident, as the pressure of the water simply pushed the plank off on the opposite side with the foregoing results, and what came near being a bad accident turned out to be a good lesson to those concerned; that in the future it would be wise to inquire into the nature of things when anything unusual happened or when anything was found out of its rightful place.

LEON L. POLLARD.

Trouble Caused by Faulty Blowoff Installation

THE WRITER recently encountered a trouble job in our plant which might prove of interest because it is probably so unusual. Our plant was situated along a river and was in the country section, so that it was possible for us to discharge our boiler blowoff directly into the river which was at a level of about 30 ft. below the boiler room floor. When the plant was installed, a pipe to carry this blowoff extended from the boiler room down to the river somewhat in the manner shown on the accompanying sketch. The pipe fitter in cutting his pipe evidently miscalculated for the horizontal run of 8-in. pipe was to have rested upon the concrete jetty wall.



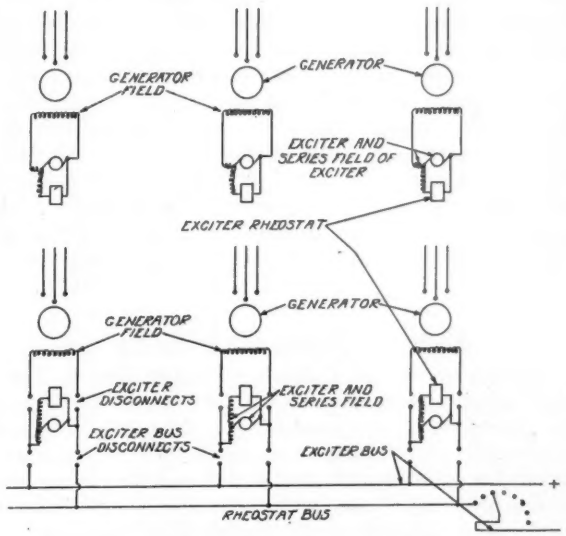
BLOWOFF LINE AS ORIGINALLY INSTALLED

Either because of cutting his vertical pipe too long, or not desiring to excavate along the lower horizontal run, the pipe was finally installed with two 6-in. blocks of wood under the 8-in. pipe where it crossed the jetty wall.

All this would have been satisfactory and was for the course of some 8 yr. until recently, during the cold spell, when we went to blow off the boilers in the morning, we found the blowoff pipe clogged and investigation showed that it was frozen up. Further search disclosed the fact that the wood blocks supporting the run of pipe had rotted away, the vertical section of the pipe sunk 5 or 6 in., and because the horizontal run was supported by the ground at the outer end and not at the base of the vertical line the line sagged to such an extent that the drips through the blowoff line were pocketed there and during the night became frozen. The line was soon thawed out and opened up, and an iron support put under the pipe to restore it to its proper level, but the incident is worthy of note as it shows the possibility there is of bringing on trouble if things are not done properly in the first place. M. A. SALLER.

Voltage Regulation

THE QUESTION of how many rheostats are really required is one that affects the total cost involved. Therefore, a few remarks upon this subject should serve to bring up several points often overlooked by electricians and others when choosing new generating equipment. This subject was broached by B. W. D. in the March 15 issue of Power Plant Engineering.



DIAGRAMS SHOWING VARIOUS METHODS OF CONNECTING EXCITERS

Where one exciter supplies current for one generator —a condition which may exist in a plant containing one main generating unit and which always exists where each turbo generator is supplied by its own direct-connected exciter—a considerable saving may be obtained by eliminating the generator field rheostat.

To consider one machine only: The generator voltage is varied by varying the field ampere-turns. The field ampere-turns may be varied (1) by varying the voltage of the exciter or (2) by varying the resistance of the generator field circuit with constant voltage on the exciter. The former is accomplished by a rheostat in the exciter field circuits, the latter by a rheostat in the generator field circuit. The first of these carries only a small current, a small percentage of the total exciter current; the second carries practically full load current of the exciter and is, therefore, a much larger, bulkier and costlier rheostat than that of the exciter.

Where there is one generator and one exciter, the generator rheostat can be eliminated, and all voltage control accomplished by the exciter rheostat which varies the exciter voltage. This means a saving in first

cost, and considerable saving in floor space. It is common practice to do away with a generator field rheostat on turbo generators with direct-connected exciters where the voltage is controlled by hand.

Frequently, a turbo generator is served by its own direct-connected exciter, but provision is required to permit obtaining excitation from another source, should the exciter be out of service. In this case, a generator rheostat is required unless the station wiring is such as to permit the one generator obtaining its excitation from a special exciter bus. When this is the case, and all generators in the station are of much the same size, one generator rheostat may suffice for any and all generators provided that only one generator is operating from the exciter bus at any one time. The wiring should be such that this rheostat cannot be connected to more than one generator field at any one time.

The accompanying diagrams indicate how an exciter rheostat suffices for the unit consisting of exciter and generator; how several generators may be connected in emergency to an exciter bus bar, one at a time, and how one rheostat may be made to serve any one of several generators should it not be feasible to vary the exciter bus voltage. There are many combinations of electrical equipment, many of them ingenious. As wiring becomes more complicated, however, it becomes more costly and gives greater opportunity for mistakes to be made. The chief value, perhaps, of ingenious wiring is that it presents a useful way of meeting emergencies.

W. B. DeMuth.

Exhaust Steam for Heating

Referring to Mr. Cultra's "Exhaust Steam Heating," April 1 issue, page 389, it has been my fortune to see an engine running condensing and heating buildings at the same time. In one case, the amount of steam exhausted was sufficient to heat a mill and the piping was so designed that all air and returns were handled by the condenser. In summer, the valves were re-adjusted so that exhaust short-circuited the heating system direct to condenser.

I had a hot water system that took its steam from the low-pressure exhaust of a compound engine and after passing through the heater went to the condenser. This system was designed for a water temperature of 140 to 160 deg. F., and I believe it hardly possible to compare any other to it in line of economy. It successfully heated two mills for a good part of the year with a vacuum of 22 in. in the low-pressure cylinder.

It is not only possible but thoroughly feasible to use the bleeder type turbine to do this work or for steam extraction. The extraction is thoroughly automatic and the pressure in the low-pressure line may be held to remarkable accuracy by a reducing valve tied in to make up any deficiency in the extractor steam.

After the reducing valve closes, should the pressure in the low-pressure line continue to increase, the turbine bleeder valve will automatically re-adjust itself to let less and less in the low-pressure line. As less steam is bled to the low-pressure line, more is fed to low-pressure stages. More power is developed than necessary. The speed slightly increases and the governor cuts off the supply, thus automatically balancing the entire cycle.

There are many plants where compound engines have been installed in which a simple engine was the proper equipment. Engineers who have a lot to say in the equipment of a new plant are inclined (or, perhaps I should say, in times past were inclined) to install a compound condensing plant.

It was my privilege 20 or more years ago to travel among steam plants as a machinist, and I found that the foregoing condition too often prevailed.

Where all the steam that an engine exhausts can be used in the process, why equip with a low-pressure cylinder and condenser?

Engines have been designed and constructed to work against pressure of 40 lb. and have proven perfectly practical and economical.

The name of being chief or operating engineer in a compound condensing plant has caused some men who have had perhaps too much to say about the general design of the steam plant to forget economy and install the more expensive unit when the cheaper was the best for the operating condition. Many times it is perfectly legitimate to take steam from the receiver of a compound engine for process work, though, as Mr. Cultra says, the ratio of the 20 and 48 by 48 would lead us to believe that the receiver pressure will be low unless the initial pressure is extremely high.

I am conversant with two engines that had ratios of 6 to 1, being designed as would be a triple expansion engine, but leaving out the intermediate cylinder. Whereas these engines probably showed very good economy, no doubt the supply of steam from the high-pressure cylinder was necessary to maintain proper receiver pressure and bleeding would have been entirely out of the question.

Tom Thumb.

Belt Theory and Practice

The article by W. F. Schaphorst in the March 15 issue contains very interesting and instructive reading matter. The following may prove of value along the same lines. A 10-hp. motor was installed in our shop to drive a shaving exhauster. Instead of finding the required speed of this exhauster, and procuring a motor accordingly, the two units were bought independently of each other and duly installed. The speed of the exhauster was so slow that good work could not be done on the woodworking machines, because the shavings were not removed efficiently. Various theories were advanced by shop hands for failure.

The speed of the motor was 1116 r.p.m. This was determined by using a revolution counter for 3 min., and dividing its indications by 3, thus reducing any possible error in starting and stopping to a minimum. The driving pulley was 7 in. in diameter. The driven pulley was 6 in. The theoretical speed of the exhauster is $1116 \times 7 \div 6 = 1302$ r.p.m. By using the revolution counter for 3 min. as before, the actual speed was found to be 1205, showing a difference of 97 r.p.m. It was 10 ft. between centers of these pulleys, and the belt was so slack that the loose top side almost touched the tight bottom side.

Having been requested to tighten this belt, I promptly complied. The average speed of the exhauster when determined as before was 1207 r.p.m., which is as

near equal as could possibly be expected. The motor took 20 amp. at 110 v., or $20 \times 110 \div 746 = 2.95$ hp.

A pulley 9.75 in. in diameter was substituted for the 7-in. on the motor. The speed was then 1070 r.p.m., hence the theoretical speed of the exhauster is $1070 \times 9.75 \div 6 = 1738$ r.p.m. The actual speed is 1650, showing a difference of 88 r.p.m. The belt is very slack and the machines have done good work ever since. The motor now takes 30 amp., showing $30 \times 110 \div 746 = 4.42$ hp. All actual speeds were determined as above described.

W. H. WAKEMAN.

Length of Wrench

THE WRENCH question has again come to the fore in the letter or page 392, April 1 number. I imagine the writer gives the manufacturers more credit than they are entitled to. If an examination of wrenches is made, as your correspondent suggests, it will be noted that different makers use different lengths for the same sized nut wrenches. One end of a wrench may take a ½-in. bolt nut and the other end a ¾-in. bolt nut. Then there is the adjustable wrench which is in use in most power plants; the larger sizes will take any size nut up to a 3-in. bolt size; the smaller will take any size from ¼ to 1-in. bolt size. The monkey wrench is in the same class.

Pipe wrenches are made along the same lines. It is quite possible to twist and split a ⅜-in. iron pipe with an 8 or 10-in. wrench. I have seen a strong-arm husky twist a valve stem apart, using his hands only. We all believe it is bad business to use a wrench on a wheel in closing a large valve under high steam pressure; but it is done and will continue to be done to some extent in defiance of all the condemnation the practice has received. It is an absolute certainty that many experienced engineers have done it for years with practically no damage to the valves. The practice is wrong. Nevertheless the careful man can do many things with safety where the careless or inexperienced man will come to grief.

Where there are a large number of big nuts to be tightened, it is a great reducer of hard work to use a long-handled wrench for the last turn or so. Using a long-handled nut wrench is seldom as dangerous a practice as using a wrench on a valve wheel where an extra leverage may cause a careless operator to ruin a valve costing a large amount of money, but neither of these practices need be dangerous to material and prove of considerable assistance to a lone worker, if the worker uses his brains. The careful, experienced worker will seldom do any material damage even if he uses the wrong tools; the careless, inexperienced worker is liable to do harm irrespective of what tools he uses.

Some writers advise engineers to cut out all stunts that may be dangerous; but engineers are doing dangerous stunts every day, some of which could and should be discontinued. Many of them, however, especially the ones which help reduce manual labor, will continue to be done no matter how much advice is given.

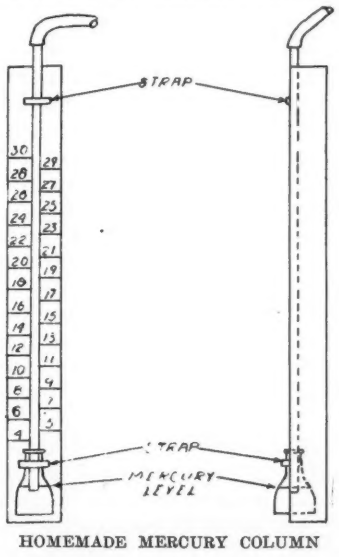
The stationary engineer must surely be a brainy, careful, or exceptionally lucky man, for very few of them are killed in proportion to those killed in other mechanical lines. The engineer's watchword should be "Be careful," whether the wrench is long or short.

JAMES E. NOBLE.

Test Your Own Vacuum Gages

ABOUT ALL that is left for the everyday engineer to do when his vacuum gages go wrong is to throw them away and buy new ones or go to the trouble and expense of shipping the offender to the factory where sometimes it will cost practically as much to put it in order as it would to buy a new one.

A certain plant had several defective gages scattered throughout the engine room and boiler room that had been inoperative for a long period of time. It was a case of buy new ones or repair the old ones, but how to repair them was a question until I made the mercury column. The sketch explains itself and was made from



HOMEMADE MERCURY COLUMN

a few odds and ends picked up around the engine room.

A 36-in. gage glass is preferable; but where the vacuum does not exceed 8 or 10 in., such as in heating systems, etc., a 12-in. glass will do.

In marking off the gage board, always start from the mercury level in the bottle and when using this apparatus always make certain that it is airtight.

J. W. SHAW.

Safety Features of Steam Boiler Accessories

MR. HILLEARY'S article on "Safety Features of Steam Boiler Accessories" certainly deserves wide attention. It is timely, not only as applied to the construction of new plants, but also for revamping existing boiler plants. In existing plants, the recommendations can be carried out on the installment plan, that is distribute the expense over, say, a year.

In the writer's experience, no serious objection can be raised to the "Y" base for mounting safety valves. Safety valve outlets should be piped through the roof. Cases are on record in which workmen who were unfamiliar with boiler house operation became frightened at the sound and sight of escaping steam. In an effort to escape, they jumped or fell and injury resulted.

The application of safety fire and ash pit doors should be extended to the side fire-inspection doors. A good type for this latter purpose is a counterweighted vertically sliding door, held from swinging outward by guides cast integral with the door frame.

It would seem that the objection raised to the use of low water alarms would apply more particularly to small plants without direct supervision. In a large plant with a foreman in charge, the water tender is not likely to rely entirely upon these alarms if his instructions have been to keep them from sounding. Emergency conditions may hold the water tender's attention at times; the sound of a low water alarm would then be a decided advantage. In this connection, the writer feels that the feed-water regulator is a "safety accessory."

In addition to safety accessories there are numerous miscellaneous applications of boiler house safety features. Passageways should be clear of steps and ample in width so that work necessary to be performed in them can be done conveniently. Overhead clearances should be such that a man can pass under them when walking erect. Platforms should be planned so that all main valves, water columns, manholes, cleanout doors, etc., are easily accessible. The width of the platform will be determined by its use. If a platform is to be used in connection with washing out boilers, allow ample room for the manipulation of tools, hose, etc. Metal runways of checkered plates, with toeboards and substantial hand rails, are to be recommended. Stairways are always preferable to ladders even when the latter are permanent. Stairways should contribute to easy and quick access to important parts of the installation and they should be so arranged that in case of accident, it would be practically impossible for a man to be trapped with no means of getting to the operating floor.

Good lighting is a safety feature, as is proper ventilation, the latter being of particular importance around ash handling equipment in basements. The writer is of the opinion that boiler house basements should be not less than 16 to 18 ft. high.

Safety guards should be placed over all gears, belts, couplings, etc. Ample clearances should be left around all machinery.

The selection of pipe materials, fittings and provision for pipe expansion are also important safety measures.

Boiler insurance and inspection are important safety features. Many large industrial concerns make thorough inspections of boilers and pipe lines, in addition to the inspections made by the insurance company. Many weak flanges, corroded screwed connections, etc., hidden normally by pipe coverings, are thus found and remedied. R. A. Fiske.

I QUITE AGREE with Warren Hilleary that mechanical atomization is the thing most nearly approaching an ideal in the use of oil as fuel. The conditions in many plants, however, are not favorable to the use of this method of atomizing, and, as always is the case, it is up to the engineer in charge to meet the conditions as they are, and make the best of them. Such circumstances will necessarily keep steam and air atomizing oil burners in many plants for years to come. Just as long as this method of atomizing is resorted to, there will continue one more cause for "explosions of gases in fire boxes." Continual attention to the regulation of both fire and draft, and a little care in handling the bypass, when the burner is so provided, will do much toward reducing fire-box explosions, from this cause, to a minimum. The bypass should always be opened before shutting off the oil, when the fire is being shut down, as a reversal of this method is often the cause of disastrous explosions.

Non-return valves, when two or more boilers are connected to one header, are, indeed, a necessity; but how we shall convince the "powers that be" of this fact is the question. In the opinion of the writer, it is just as much within the jurisdiction of the boiler code to deal with non-return valves, as it is to deal with safety valves, blowoff valves and other safety devices. The use of these valves on all boilers in a battery, having a common header, should be made just as compulsory as is the use of any other well recognized necessity of safety.

High and low water alarms have such few advantages, that when considered with their unreliability, nobody should hesitate to discontinue their use. This is another place where the boiler code, in my opinion, should take emphatic and positive action against the use of such contrivances.

Pressure gages should be provided with a siphon, which fact, I believe, is already emphasized by the code. It is at least made compulsory by law, in some states.

Water columns should have ample capacity, be installed without intervening valves, with plugged crosses, rather than elbows, at every turn in the pipe. All pipe below the water level should be brass, while that above should be extra heavy iron. J. M. Row.

READING Mr. Hilleary's article has brought to my mind a similar device for warning the engineer of high receiver pressure as he mentions for warning boiler attendants of high boiler pressure, viz., the little pop valve of ¾ in. or less.

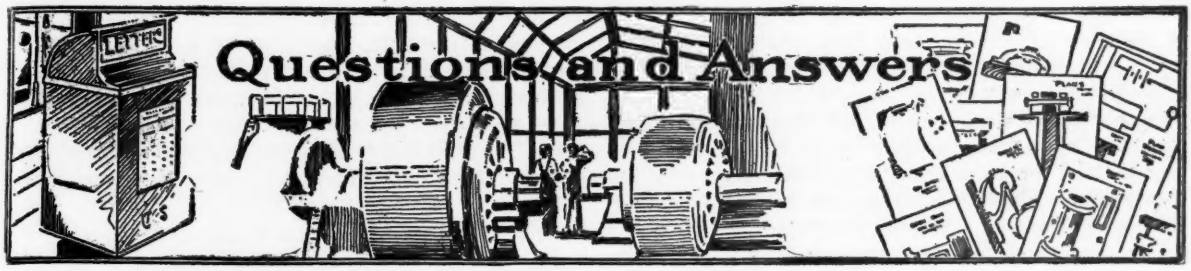
In the case which I shall cite, a ¼-in. angle valve was made into a relief valve and a whistle attached. The only atmospheric relief on an engine developing 2500 hp. was a 2½ or 3-in. pop safety valve set at about 5 lb., and this valve blew across the upper deck. The engine was a vertical cross compound with a Corliss gear, the low-pressure cutoff being hand regulated and the unit being served by a surface condenser.

Incidentally, the receiver relief valve blew across one stairway to the upper deck, but another stairway was provided, which made it possible to escape.

If the air pump or circulating pump stopped to rest before the operating engineer or oiler could get the throttle half closed, the relief valves would drive them from the upper deck and sometimes even out of the room, steam being shut off at the main stop valve.

After 20 or more years of this playing tag every time a pump got tired, the relief valves were piped to the atmosphere outside the engine room; but, should a heavy load come on unexpectedly, the receiver pressure would climb until the receiver relief valve would blow and perhaps not be noticed for a few minutes.

To eliminate this condition, the little relief with whistle attached was installed and now when within 8 or 10 lb. of maximum pressure, the little whistle blows and warns the attendant. Tom Thumb.



Cause of Low Initial Pressure at One End of the Cylinder

IN ANSWER to an inquiry in the March 15 issue of Power Plant Engineering, in regard to indicator diagram from a McEwen engine running 275 r.p.m., I submit the following concerning the difference in initial pressure between head and crank end.

Analyzing the diagram on page 339, note the following: first, the low initial pressure occurs at head end of the cylinder; second, compression begins earlier and does not rise as high at the same end; third, the expansion line from the head end is not so steep as from the crank end; fourth, lead shows a little late at the head end.

Now, assuming that the valves of the engine are not in bad shape, the facts mentioned above indicate a larger clearance at head end than at crank end, consequently it requires more steam to fill the clearance volume at the beginning of the stroke. The rate of flow of steam into the cylinder is a function of the pressure difference between valve chest and cylinder and as this approaches zero the rate of flow decreases, so that when the pressure in the cylinder is nearly as high as in the valve chest, it requires more time to build up pressure and with equal port openings, the end of the cylinder requiring the least amount of steam will show the highest pressure.

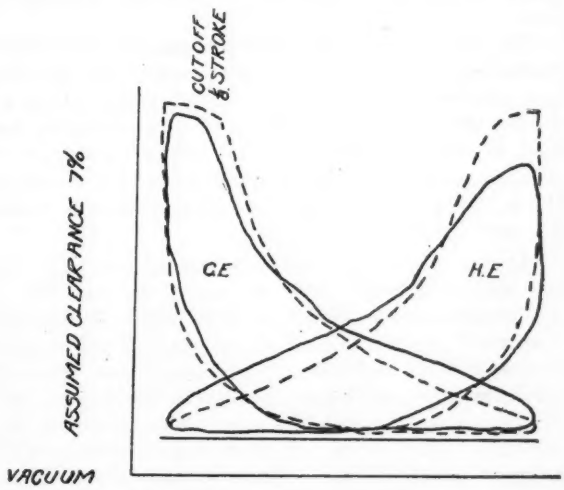
There is always some loss in pressure through the ports of an engine; but if every condition at each end of the stroke is the same, the initial pressure will be the same, but when any of the conditions are different, it is shown by a loss or gain in pressure.

The writer would suggest decreasing the clearance at head end as much as possible with safety and then indicating the engine again, and if no advantage is shown, the port openings should be looked at to see if they are correct; although, if this is a single-valve engine, it might not be possible to make any change in them without unbalancing the load on either end of the cylinder. S. E. B.

REFERRING TO C. W. B.'s card, it would appear that the unequal heights of the different ends are caused by the lead being unequal. The valve motion seems to be disorganized; admission, cutoff, expansion, release and compression—all being different in their respective ends. The back pressure also is higher in the head end than in the crank end.

In the crank end admission appears to be timed right. The expansion line does not follow the hyperbolic curve any too closely, so I think it possible that the steam valve is leaking. Release also occurs late.

In the head end admission is too late. The expansion line is worse than in the crank end, crossing the hyperbolic curve much too high and dropping again where it should rise. Release seems to be late, and compression, while starting plenty early enough, does not make the curve high enough.



CARD FROM A 12 BY 13-IN. MC EWEN ENGINE SUPERIMPOSED ON A THEORETICALLY PERFECT DIAGRAM

Summing up, I should advise an inspection to determine whether or not the lead is equal for both ends, also see if the piston rings are tight and the cylinder truly cylindrical. There is also a possibility that the steam valve is leaking.

The accompanying diagram compares your card with a theoretical diagram, assuming cutoff at ⅛-stroke and a clearance of 7 per cent. H. A. WOOD.

Design for Bell Transformer

I WISH to make a transformer to step down 115 v. a.c. to the few volts for ringing a single door bell. I would like to have dimensions for the core and size of wire for primary and secondary coils and the number of turns for each coil. H. O. H.

A. It is a difficult matter to design a small bell ringing transformer, as it is uncertain as to how far data which apply to high voltage transformers of considerable power will apply to these small devices. We have, however, designed one which, we believe, will function properly; but only testing it will disclose whether or not the design is the best that could be employed for the purpose.

The core should be built of No. 26 gage sheet iron in the form of a rectangular frame to a thickness of 0.6 in. The side strips should be 3.4 in. long by 0.6 in. wide and the ends 1.4 in. long by 0.6 in. wide. The pieces should be stacked with alternate ends protruding 0.6 in. so as to make the total length of the sides 4 in. and that of the ends 2 in. The winding goes on the side pieces. These bundles should be held firmly together by tying or clamping the ends.

On one of the long sides, after covering with a thickness of press board or two layers of oiled silk, wind 2180 turns of No. 29 B. & S. gage copper wire. This will require 472 ft. or 0.181 lb. of wire. On the other side wind 90 turns of No. 12 gage wire which will amount to 19.5 ft. or 0.385 lb. The outside of the coils should be wrapped with cotton tape to protect the wire, and, of course, press board or fibre heads should be put on at each end to keep the winding in place.

The end pieces should then be placed in position, dovetailing the ends with those of sides, and the corners clamped together firmly probably by means of wooden strips put across the ends and extending beyond so that they can be drawn up by screws.

This transformer is designed to take current at 115 v., 0.174 amp., 60 cycles, and to deliver 4 v. and 4¼ amp. from the secondary.

As for the design, we will first assume that the bell and transformer will require 20 w. At 115 v. this would mean a current of 0.174 amp. As the bell is assumed to operate on 4 v., the ratio of transformation is $4 \div 115 = 0.0348$. The transformer efficiency can be assumed as 85 per cent, which would mean that 3 w. are lost, 2 w. due to copper losses and 1 w. due to core or iron losses. With a flux density of 8500 gauss at 60 cycles, the total core losses for 0.015 in. laminations is 0.376 w. per cu. in. The core volume is then found to be $1 \div 0.376 = 2.66$ cu. in. If the mean total length of the core is 9.6 in., as it would be with the dimensions we have adopted, the cross-sectional area would be $9.6 \div 2.66 = 0.36$ sq. in. and the dimensions would be 0.6 by 0.6 in.

The number of turns in the primary may be determined for the equation

$$N. = (10^8 \times E_1) \div (\sqrt{2} \times 3.14 \times f \times B \times A)$$

where E_1 = primary voltage, f = cycles per second, B = flux density = 8500 gauss times 6.45 = 55,000 maxwells per sq. in. Evaluating this equation, we get

$$N_1 = (100{,}000{,}000 \times 115) \div (1.414 \times 3.14 \times 60 \times 55{,}000 \times 0.36) = 2180 \text{ turns.}$$

As the core is 0.6 in. square, the perimeter is $4 \times 0.6 = 2.4$ in. and the length of the mean primary turn will be about 2.6 in. With 2180 turns the total length of wire will be $2180 \times 2.6 = 5660$ in. or 472 ft., which will weigh 0.181 lb.

Of the total copper loss, 2 w., 60 per cent or 1.2 w. can be assumed to be in the primary windings; then the $I_1^2 R_1$ loss of the primary is 1.2 w. As the current here is 0.174 amp., $I^2 = 0.0303$ and R is found to be $1.2 \div 0.0303 = 39.6$ ohms. The resistance per foot is then $39.6 \div 472 = 0.0840$ ohms which would call for No. 29 gage wire.

The number of turns on the secondary

$N_2 = 0.0348 \times 2180 \div 0.85 = 89$, or, say, 90. The secondary current is $0.174 \div 0.0348 \times 0.85 = 4.25$ amp. The secondary $I_2^2 R_2$ loss is 0.8 w. from which $R_2 = 0.8 \div 4.25^2 = 0.0444$ ohms. With a current density of 1032 amp. per sq. in., A_2 can be found from the equation $I_2 \div A_2 = 1032$ to be $4.25 \div 1032 = 0.0041$ sq. in. or $0.0041 \times 1{,}274{,}500 = 5230$ cir. mils, which corresponds approximately to No. 12 B. & S. gage.

Repairing Girth Seam Cracks

REFERRING TO G. B.'s question in the Feb. 15 issue, as to how to repair the fire cracks at the girth seams in his boilers, if the cracks run from the rivet holes to calking edge, I would suggest the following repairs: Cut out the rivets, ream the hole and put in a larger rivet with a countersunk head; countersink the hole so as to fit the rivet head. This will usually stop the leak. It has been found that the sheets were not drawn tightly together when first riveted in some cases where the leaks could be stopped; in a case like this, I would suggest a number of rivets being cut out and tack bolts put in every other or every second hole, the plates drawn tightly together and then riveted. F. E. L.

Flow of Steam

HOW MANY POUNDS of steam will flow into a barrel of water through a one-inch iron pipe having three elbows and one globe valve, in a given length of time, if the boiler pressure is 60 lb. per sq. in. gage? The boiler in question is a 6-hp. locomotive type furnishing steam for heating water. When the steam valve is open, the boiler primes badly. Perhaps the boiler is of insufficient capacity to furnish steam at full opening of a one-inch valve. W. G. S.

A. The question of determining the amount of steam which will flow through a given line in a given time is subject to so many considerations that it is difficult to determine beforehand exactly what this amount will be.

Equations for flow vary considerably. We give one here which seems to give fairly consistent results, but should not be relied upon entirely.

$$W = K \sqrt{pg \div L}$$

where W is the pounds of steam flowing per second, K is the constant depending chiefly upon the size of the pipe which, for a one-inch pipe, would be 0.75; p is the pressure drop; g is the mean density of the steam, which can be taken at 45 lb., at which pressure it is equal to 0.1065; L is the equivalent length of straight pipe.

Another formula gives the following equation for the length of straight pipe equivalent to an elbow:

$$L = 75\,d \div (1 + 3.6 \div d).$$

For one-inch pipe where there are three elbows, this would amount to 49 ft. For the straight pipe equivalent to one globe valve.

$$L = 114\,d \div (1 \times 3.6 = d),$$

and for a one-inch pipe this would be 25 ft.

The length of pipe is not given in this problem, but for simplicity we will consider that it is 26 ft. long, making a total equivalent pipe length of 100 ft.

Substituting these figures in the first equation, we get

$$W = 0.75 \times \sqrt{60 \times 1.065 \div 100} = 0.19 \text{ lb. per sec.,}$$

which is equivalent to 684 lb. per hour.

As one boiler horsepower is equivalent to the generation of 34.5 lb. steam from and at 212 deg. per hr., the boiler horsepower generated in this case is approximately 20 hp., from which it will be seen that you are overloading your boiler approximately 233 per cent. This would account in part, at least, for the priming which you experience.

Power Developed in a Hydraulic Turbine

CAN YOU tell me how much power a turbine water wheel will develop for every 10 ft. of fall with an 8-in. stream flowing to the wheel? How much fall would be required to run a centrifugal pump to pump the same water back to the original source? A. L. M.

A. The theoretical energy in a body of falling water

$E = \frac{1}{2} m V^2$ where $m = W \div g$ and $V = \sqrt{2gh}$.

W is the weight of water passing a given point in one second, hence is equal to:

62½ (the weight of water per cu. ft.) × the area of the stream in sq. ft. × the velocity.

The equation then becomes:

Energy, $E = \frac{1}{2} \times 62\frac{1}{2} \times A \times \sqrt{2gh} \div g \times 2gh$.

This reduces to:

$$E = 62\frac{1}{2}\ A \times \sqrt{2g} \times \sqrt{h^3}.$$

Keeping the first three factors in this expression constant for any given condition, the energy available in a falling body of water is proportional to the 3/2 power of the height.

In these equations, A is the area of the stream, g is the acceleration due to gravity which equals 32.16 ft. per sec., h is the height of fall. If you have water falling a height of 10 ft., in an 8-in. stream, the energy at the bottom will be:

$62\frac{1}{2} \times 0.7854 \times 2/3^2 \times 64.4 \times \sqrt{10^3} = 5540$ ft.-lb. per sec.

Dividing this quantity by 550, we get the theoretical horsepower developed, which equals 10.05 hp. If the efficiency of the turbine or waterwheel is 60 per cent, you would be able to get 6 hp. out of this stream. In order to pump this quantity of water to this height, we will use a pump with the assumed efficiency of 60 per cent, hence the horsepower required will be $10.05 \div 0.6 = 16\frac{1}{2}$ hp.

If it is required to pump this water in an 8-in. stream to a height of 10 ft. with a pump having an efficiency of 60 per cent driven by a turbine also having an efficiency of 60 per cent, the water power supplied to the turbine must be equal to $10.05 \div 0.6 \div 0.6 = 27.92$ hp. If this energy is supplied by an 8-in. stream, the height of fall must be as determined from the proportion $\sqrt{h^3} : \sqrt{10^3} :: 27.92 : 10.05$ from which it will be seen that h = 19.75 ft.

Tangents

DO A SMALL CIRCLE and a very large one, when resting on a straight line, touch the same amount of the line or does the large one touch more? I say the large circle touches more because the straight line runs along the curve of the circle a greater distance than on the small one. My friend says a dime placed on edge on a perfectly level track doesn't touch any less than the six-foot drivers of a locomotive. I say the drivers touch more. V. L. M.

A. Practically you are right, theoretically you are wrong. A straight line can be tangent to a circle at only one point. In the case you cite, however, of a locomotive driver on a track, the weight of the locomotive sinks the wheel into the track, deforming both of them from their true outline. The track is then no longer a straight line but conforms, for a short distance, to the outline of the wheel which is no longer perfectly circular and the track is then no longer tangent to the wheel. The length of contact would be greater on a locomotive wheel than on the dime because of the difference in pressure. In each case, the bearing pressure assumes the same value where the same materials are used. If the same pressure were applied to two wheels of different diameters resting on a rail, the length of contact would be the same in both cases provided the elastic limit of the materials were not exceeded.

Determining Receiver Pressure

I AM OPERATING a Corliss tandem compound 13 by 26 by 30-in. engine with steam pressure at 145 lb. gage in connection with a jet condenser. What receiver pressure would you advise?

2. What would be the correct receiver pressure to carry, operating noncondensing?

ANSWERS

THE CORRECT receiver pressure which should be used on this engine can be found from the following equation:

$$P_2 = P_1 \div \sqrt[y]{R \times P_1 \div P_3}$$

where P_2 is the receiver pressure, P_1 is the initial pressure, and P_3 is the back pressure, all being measured above absolute zero. R is the ratio of expansion.

Substituting the values you have given us in this equation: $P_2 = 145 \div \sqrt[y]{4 \times 145 \div 2} = 145 \div 6.64 = 21.85$ lb. abs. This corresponds with a pressure of 7.15 lb. gage.

2. If the engine is running noncondensing, exhausting at atmospheric pressure, the receiver pressure, $P_2 = P_1 \div R$. Evaluating this equation, we get: $P_2 \div 145 \div 4 = 36.2$ lb. abs., or 21.5 lb. gage.

Centrifugal Pump Efficiency

AT WHAT speed should a centrifugal pump operate to give best efficiency? A. P. J.

A. For best efficiency, a centrifugal pump must be carefully designed for the particular job for which it is intended, as the curvature of the blades, diameter and speed of the impeller, the number of stages, etc., have a very important bearing on the performance of the apparatus. Pumps of this variety are designed to have entirely different characteristics for different kinds of operation.

For instance, one pump will hold its efficiency at comparatively a constant point over a big range in the head pumped against, whereas another pump can be designed to maintain its maximum efficiency over wide ranges in speed and capacity. It is obvious that these two pumps could not economically be interchanged. In the first case, any variation in speed would cause a material decrease in the efficiency, whereas in the second case, any marked change in the head would cause a decrease in efficiency.

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Primary Horsepower in Manufactories

Because of the extensive and growing use of mechanical devices to replace manual labor in industry, this has been appropriately termed the mechanical age, and the engineer is vitally interested in every power-driven device which comes upon the market, for as these increase the relative importance of the power plant to other departments of the factory also increases with added responsibilities and greater opportunities for the engineer as an individual.

As an indication of the importance of power to industry, engineers of the country should be intensely interested in the census report now being compiled by the Department of Commerce for the year 1919. This census covers a number of items in regard to the manufacturing industry of the country such as the number of establishments, persons engaged in manufacture, primary horsepower, capital, cost of service, materials, value of products and the value added by manufacture. Of principal interest to the power plant engineer is the relation of primary horsepower to the number of persons engaged in manufacture. Unfortunately the figures from all states are not as yet available and it is not expected that the complete census will be published until about a year hence, and furthermore the figures available come principally from states where manufacturing is not the main industry; nevertheless they do reflect the trend of practice during the years of the war.

States from which figures are available are North and South Dakota, Nebraska, Montana, Wyoming, Colorado, Idaho, Utah, Nevada, New Mexico, Arizona, Vermont and Delaware. With the exception of Nevada, which showed a decrease of 26 per cent, all of these states showed substantial increases in primary horsepower installed in factories in 1919 over 1914 ranging as high as 84.4 per cent in the case of Montana, but only five show that the horsepower per person has increased.

Arizona showed an increase from 6.82 horsepower per person in 1914 to 9.67 in 1919; Montana from 5.6 to 8.17; Utah from 3.48 to 4; Vermont from 4.68 to 4.78, and Delaware from 2.52 to 2.55. The greatest reduction among the states given was in Nevada where the horsepower per person in 1914 was 4.57 and in 1919 was 3.8.

Certainly if mechanical power is to replace manpower to any great extent in factories the ratio of primary horsepower to persons engaged must increase rather than decrease as has been the case in most of the states from which figures are available. The census figures, however, are not all that might be wished for. Could there have been obtained the number of horsepower-hours used in factories rather than primary horsepower, a much better comparison could be made.

It is useless to make a comparison of horsepower to persons engaged in different manufacturing industries, but it does behoove every engineer in a factory to know whether or not his power plant is doing its share of the factory work as compared with competing factories. The use of automatically operated devices has replaced many men in industries and their installation in nearly every case increases the importance of the power plant to the factory and with it grows the position of the engineer in industry.

What Do You Know?

Those of us who have become accustomed to the annual task of taking an inventory of the plant at the close of the year will, no doubt, appreciate the value of the procedure. It enables us to know just where we stand, and what, and what not, to order.

But do you ever take an inventory of yourself? No doubt, you are well acquainted with the more or less common problems that arise in connection with your work but we are often called upon to answer questions, the correct answers to which do not lie within the realm of our experience. It is then that we make use of the experience of others.

Are you prepared to answer such questions? For instance, do you know—

The practical value of the air lift?

That a chemical process exists in which the scale forming impurities in your feed water are instantly removed without the addition of any chemicals, whatsoever?

The characteristics of Iowa coal?

What is meant by the most economical percentage of CO_2 for a given furnace?

Why your boss refused to buy that new equipment you asked for, and which you are certain you need?

The relative advantages and disadvantages of 60 or 25-cycle currents?

Why American manufacturers are not selling machinery abroad?

How to adapt space conditions in your plant to take care of increases in capacity?

That condenser tubes and tube sheets may be effectively cleaned while the condenser is in operation?

How a horse may be used in handling coal?

How steam is used in the canning industry?

How to eliminate noise in a heating system?

How your refrigerating plant is affected when the liquid in the gage glass on the ammonia receiver falls out of sight?

The leaders in your profession?

Why a compound engine is often less efficient than a simple engine would be if installed in its place?

How to determine the power developed by a hydraulic turbine?

Do you know that unless you can answer each one of the above questions, you have not obtained maximum benefit from the pages of this issue?

Co-operation

Individual effort is good; co-operation is better. Many an engineer has advanced a considerable distance by use of the former; more have gone nearly the whole distance because of the latter. Individual effort, co-operation and system spell success.

Any experienced chief engineer could tell about the unsatisfactory results obtained in plants when the different shifts, or the individual shifts, did not pull together.

Lack of co-operation means dissension and jealousies among the men, resulting in direct loss in good service to the plant.

Co-operation means that the operating staff will be made familiar with the power costs, such as fuel, oil, packing, ash handling, and the hundred other items often known only by the chief or the manager. Co-operation means that the men at the top, near the top, and in the middle will take an interest in the men near the bottom, and by their actions and treatment unmistakably show that such interest is genuine; each man must be interested in advancing all those under him as well as being interested in his own advancement.

Co-operation will encourage the man below to look up to a higher goal; it will convert a plodder into a hustler in the endeavor to reach the goal. Co-operation will give the under man an incentive to get knowledge of power plant engineering; this is a point where individual effort will prove valuable. Successful engineering means concentrated study in work and reading.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

How To Handle Your Competitor

By Dr. Frank Crane

IT IS a mistake to suppose that you have to fight your competitors. Nothing was ever permanently gained by fighting. For fighting of any kind is pure destruction.

Your competitor should not be your enemy. He can be your friend.

This is based on the natural law that no one person can suit everybody. One man's personality attracts some and repels others.

This is proved by the fact that in any big city, business houses in the same line group together. We find most of the piano houses in one part of the town. The silk merchants, the hat manufacturers, and so on, each have their district. This proves that in the practical working out of business it pays a man to co-operate and get in touch with his competitors.

Don't hate your competitor. Hate is always expensive. Get acquainted with him. You may learn something.

Don't knock your competitor. It sounds bad, and it is bad. Be a good sport. Play the game. Keep good-natured.

Beat your competitor if you can, but remember that the surest way to beat him is to know more, to give prompter service and be more courteous. Don't cut wages. Insist on a living salary, and be worth it.

Your competitor will do you a deal of good if you keep your eyes open. He will keep you from slumping. He will make you energetic, careful, more attentive to business, and altogether will be a good tonic for you, if you know how to use him.

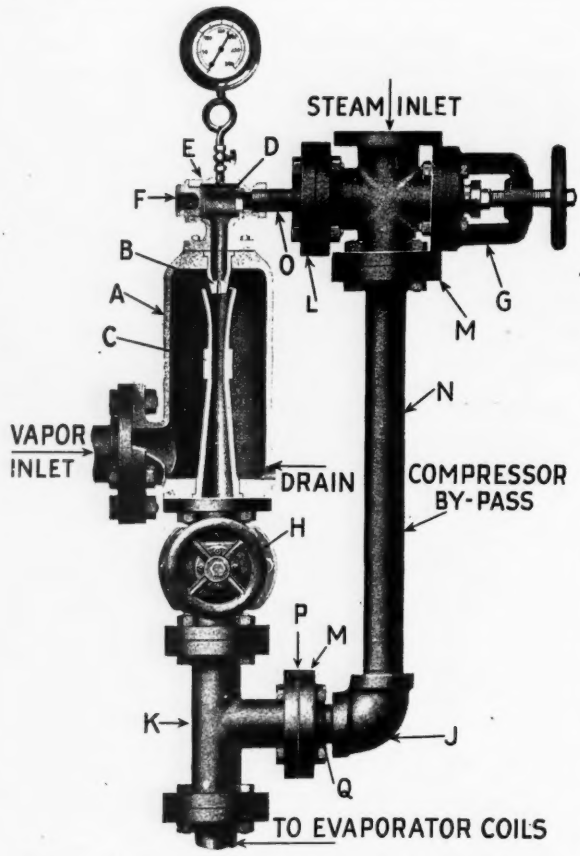
There is work enough for both of you. Go after it.

Copyright, 1921, by Dr. Frank Crane

Regenerative Compressor

A REGENERATIVE compressor, which has just been placed on the market, designed for installation on evaporators, for use during periods of reduced evaporator capacity, permits evaporator operation at an efficiency much greater than can be secured by the evaporator operating alone, single effect.

It is customary to install evaporators on board ship of a size suitable for the maximum distilled water requirements at full speed; but it is evident that there are many occasions when this maximum evaporative capacity is not required, as for instance, when a vessel is operating under reduced speed or is in port. During these periods, the distilled water requirements are often as low as 25 per cent of the rated evaporator capacity. It is during the time when the evaporators are operating at capacities less than rating that this regenerative compressor may be utilized to increase largely the evaporator efficiency.



SECTIONAL VIEW OF THE REGENERATIVE COMPRESSOR

This increase in evaporator efficiency is accomplished by compressing and delivering to the evaporator coils a portion of the vapor taken from the evaporator. This vapor, together with a certain amount of boiler steam, makes up the total steam required for evaporator operation and without the use of the regenerative compressor, all of this steam would have to be supplied by the boiler.

The apparatus is essentially a jet flow compressor, the function of which, as described above, is to entrain and compress by means of live steam a part of the vapor produced by the evaporator and this entrained vapor is in turn led to the evaporator coils together with the boiler steam.

Referring to the illustration: High-pressure boiler steam from the boiler (not to exceed 250 lb. per sq. in. pressure) enters at the steam inlet, the valve G being set so as to close the compressor bypass. This allows the steam to enter pipe O and pass through strainer D and then downward through steam nozzle B. The steam leaves this steam nozzle at high velocity and enters diffuser nozzle C.

Part of the vapor from the evaporator passes through valve R and through the vapor inlet of the compressor into the body of compressor A and then through the annular space between steam nozzle B and diffuser nozzle C.

By reason of the high velocity of the steam passing from nozzle B, the vapor is drawn into diffuser nozzle C and compressed to a pressure considerably above the pressure of the vapor in the evaporator. The mixture of steam and vapor passes from diffuser nozzle C through valve H and fitting K and then into the coils of the evaporator where it gives up its latent heat to the brine in the evaporator shell, thus producing vapor and completing the operation.

If it is desired to bypass the compressor and operate the evaporator in the usual manner at rated capacity, the various valves may be adjusted accordingly. There is an orifice plate, P, between flanges M and fitting K, the size of the orifice in the plate being designed to insure rated capacity of the evaporator. This orifice plate insures a steady output from the evaporator and reduces the tendency to prime.

Hydraulic Absorption Dynamometer

AN HYDRAULIC absorption dynamometer designed by Wm. Froude of Worcester, England, has recently been introduced in this country. The machines are adaptable for large power ranges and are made in sizes that will absorb up to 5000 b.hp.

The apparatus consists, primarily, of a casing mounted on anti-friction bearings, in which a rotor, attached to the crankshaft of the machine to be tested, revolves. On each of the two faces of the rotor there are semi-elliptical pockets separated by oblique planes. In the same way, the two internal faces of the casing are pocketed. Water circulates through these pockets and is churned up by the motion of the rotor. The friction thus produced absorbs the power put into the rotor. With the revolution of the rotor, the casing simultaneously tends to revolve, due to the force transmitted from the rotor through the water. Rotation of this member is prevented by the suspension of a weight from the end of a horizontal lever arm. The weight thus carried is variable and can be adjusted so as just to balance the turning effort exerted by the casing for all conditions of load. The machine is so constructed that the entire turning effort of the prime mover is transmitted to the casing, without deduction. Even the torque absorbed by the bearings and gland packing of the dynamometer is registered at the end of the lever arm.

These machines use water at a rate of about 3 lb. per b.-hp.-hr. For this rate, the temperature of the water is raised from 70 deg. to about 180 deg. F. For higher initial temperatures, the rate will be increased and conversely for a lower temperature it will be reduced. The outlet temperature should not be allowed to exceed 180 deg. For best results the head pressure should be as constant as practicable and for this reason a supply tank is usually provided in which the head can be maintained constant by a float valve.

One of the advantages claimed for this machine is the large range in capacity. The maximum being, in some types, 100 times the minimum. This feature enables one prime mover to be tested by the same machine at many different speeds, or a large number of different engines of various capacities may be tested on one dynamometer. As the machine is practically silent, any slight noise developing in the engine under test can be immediately detected. This machine imposes a purely torsional resistance on the prime mover and therefore subjects the engine bearings to no load for which they were not designed.

There are two distinct types of this machine designed for high and low speeds. The low-speed machines are built for speeds from 80 to 800 r.p.m. and for capacities of from 6 to 2500 hp. The high-speed dynamometers are capable of speeds from 100 to 4000 r.p.m. and have capacities up to 5000 hp.

A New Engine Indicator

ALTHOUGH the steam turbine has displaced many reciprocating steam engines, the demand for engine indicators is even greater today than in the past on account of the increasing number of gas and oil engine installations.

The advent of higher steam pressure and temperature as well as the high pressure, temperature and speed of the internal combustion engine has made it necessary to modify the design of engine indicators to meet these new conditions.

The inside spring indicators are very unsatisfactory for high temperature work on account of the inaccuracy and permanent deformations in the spring. To withstand the higher pressures, means greater strength and rigidity; but in order to give satisfactory operation at the high speeds, the strength must be increased without adding to the weight of the moving parts.

These new conditions have been met in the new Maihak type of engine indicator. The piston of the indicator is attached rigidly to the piston rod and the latter is accurately guided centrally by passing through the cylinder cover. The spring support and cylinder cover is all in one piece and is machined in one setting, so that extreme accuracy results. The cylinder of the indicator is fitted with a bronze sleeve which is easily removable, permitting the use of other size sleeves and pistons so that one spring can be used for several pressures.

Between the piston and the cylinder cover, ample space is provided for air circulation which prevents the transmission of heat to the spring. To protect the spring still further under unfavorable conditions, a plate of vulcanite is placed on the under side of the cylinder cover. Openings to permit air circulation also take care of any leakage past the piston and insure atmospheric pressure on this side.

The pencil lever is made from one piece and is forked at the end so as to pass around the spring support. This bifurcation of the pencil lever makes it possible to secure strength without great weight. The system of levers employed to transfer the piston movement to the pencil point is such as to produce a practically straight line motion with the minimum number of joints. The design permits changing easily from right or left hand as required.

The drum is of standard type, the spring tension being readily adjustable for the different speeds. Each drum has a double cord race so that two indicators may be driven from a single reducing motion.

The total weight of the moving parts of the indicator used for speeds up to 1500 r.p.m. is only 0.4 oz., yet several have been in use for 4 or 5 yr. under unfavorable conditions without a repair.

Perhaps the most valuable feature of this type of indicator is the power integrator attachment for determining the average power developed. This attachment will give the mean power developed by the engine over a given period of time regardless of variations in load, steam pressure or method of governing. Supposing that an engine is operating at 200 r.p.m. and indicator cards are taken at 5-min. intervals. This means that only one card in one thousand is used in computing the horsepower, and yet there will probably be no two cards alike. Those familiar with taking cards from internal combustion engines know the great difficulty in getting average results. If the hit-and-miss method of governing is used, only one card may be produced in several revolutions and it is almost impossible to obtain the average horsepower in the usual way.

The power integrator consists of a counter provided with a wheel which bears on the circular top of the indicator drum. The wheel is capable of being moved in and out from the center of the drum by a system of levers attached to the indicator piston. As the drum oscillates, the wheel records the area of the card in the same manner that a planimeter would. The area integrated is that of a card that would be drawn on a circular chart and which would therefore be distorted. The integrator, however, automatically takes this into account. To determine the horsepower developed in a cylinder, it is necessary only to determine the counter readings before and after a certain time period during which the apparatus is in operation.

If A = net area of engine piston in sq. in., L = length of stroke in ft., C = integrator constant, T = time integrator is in operation in min., D = difference in counter readings during this time interval, S ÷ length of diagram in inches, M = scale of spring, then the horsepower is given by the equation:

$$\text{Hp.} = (C \times D \times M \times L \times A) \div (T \times S \times 33{,}000)$$

By comparing this equation with the usual horsepower equation

$$\text{Hp.} = P \times L \times A \times N \div 33{,}000$$

it will be seen that D is simply the total area in sq. in. of all cards taken during the time T. Another comparison will show that the average M.E.P. equals $(C \times D \times M) \div (N \times T \times S)$ or that the average area is equal to $(C \times D) \div (N \times T)$.

To use the power integrator it is only necessary to place the indicator in operation in the usual way, then lower the counter wheel on top of drum and take the time. After a given interval of time the counter wheel is raised and a reading of the counter taken. This reading, when multiplied by a constant, will give the average horsepower developed during that time and it is a real average because every card produced during that time was counted exactly according to its size and shape.

If the average mean effective pressure is wanted instead of the horsepower it is only necessary to take the number of revolutions during the time that the counter is operating. No skill is required and the calculation is a simple multiplication.

The integrator is a separate attachment, and need only be used when desired and it does not interfere with taking cards in the usual way.

Spring Meeting of the A. S. M. E.

THE 1921 spring meeting of the American Society of Mechanical Engineers is to be held in Chicago, May 23-26, at the Congress Hotel. Well developed programs will be presented by the professional divisions of the society devoted to forest products, fuels, machine shop, management, material handling, power, railroad, and a specially important session will be devoted to training for industries. The Chicago Committee, jointly with the Western Society of Engineers, is preparing a session on "Chicago as the Rail-Water Gateway."

En route to the meeting, the Society, jointly with the Society of Automotive Engineers, will stop at McCook Field on Saturday, May 21, for an inspection of the facilities of the field.

On May 27-28, the Friday and Saturday following the meeting, a joint excursion with the Army Ordnance Association will proceed to Rock Island Arsenal, where the Ordnance Division will present papers and enjoy an inspection of the plant.

The fuel division session will be devoted to the consideration of the topic "Utilization of Mid-Western Fuels," and presentation will be made by men who have had broad experience in this field. The papers to be presented are as follows: Recording Ash-Pit Loss from Chain-Grate Stokers, E. G. Bailey; Boiler Tests with Pulverized Coal, Henry Kreisinger and John Blizard; Limitations of Mechanical Stokers Utilizing Mid-West Coals, E. H. Tenney; Capacity and Efficiency Limitations of Stokers Using Mid-West Coals, John E. Wilson; Discussion of Smoke Production with Reference to the Health of the Community, Dr. John D. Robertson; Latest Requirements of the City of Chicago in Furnace Design with Special Reference to Handfired Boilers and Limits of Each Design, Frank Chambers.

The paper by Mr. Kreisinger and Mr. Blizard gives the result of the tests made at the Oneida Street Station of the Milwaukee Railway & Light Co., which will be visited during the meeting.

At the general sessions, William M. White will deal with the Hydraucone Regainer. This paper will outline the development of this device and its successful application in hydroelectric development leading to high water wheel efficiency and more economical power house construction. A new method of conducting capacity tests on low vacuum pumps will be given by Snowden B. Redfield, who will explain the use of low pressure nozzles and outline a simple method of conducting tests. The subject of boiler water analyses will be presented by J. R. McDermet, who will emphasize the necessity for more careful analyses of boiler waters to reduce corrosion in boilers and economizers under present high steam pressures and high degrees of superheat. H. B. Reynolds will present the results of a series of tests on a 30,000-kw. steam turbine installed at the 59th St. Power House of the Interborough Rapid Transit Co. of New York.

Industrial Chicago has many things to show the mechanical engineer, and is going to throw them open to inspection by those attending the Spring Meeting. The places of interest to power plant engineers which offer to entertain guests in this way are Commonwealth Edison Co., modern turbine central station at Fisk St.; Crane Company, manufacture of valves and fittings in cast iron, malleable iron, steel and brass, the fabrication of pipe work; Underwriters Laboratories, testing of appliances and devices for fire prevention, and the Milwaukee Railway & Light Co.'s Lakeside plant, trip by rail to Milwaukee, boilers fired with powdered coal.

News Notes

THE EXECUTIVE BOARD of the American Engineering Council held its regular meeting in the rooms of the Philadelphia Engineers' Club April 16, and at the close of the meeting, Mr. Hoover tendered his resignation as president of the Federated American Engineering Societies. Mr. Hoover stated to the executive board that it was with a sense of keen regret that it became imperative for him to resign because of his cabinet position. It was obvious that he could not continue to be president of the Federated American Engineering Societies, which was interested in promoting certain government and legislative activities, that as a cabinet officer he would have to pass upon. The executive board fully appreciated Mr. Hoover's position and accepted his resignation. The great service that Mr. Hoover has rendered as president, his enthusiastic support, his broad conception and contacts have given great impetus to the movement for unity and co-operation in the engineering profession and, while he cannot continue as president, he will continue to give his enthusiastic support and advice.

CHAIRMAN of the House Committee on Coinage, Weights and Measures has announced that extensive hearings will be held on metric bills in the near future. He had declined to call a meeting last session but is now in favor of studying all details of this question.

DR. ERICH W. ZIMMERMAN, professor of commerce of the James Millikin University, Decatur, Ill., has been detailed by the United States Bureau of Mines to make an investigation regarding the fuel situation in the Dakotas, Minnesota, and nearby states with a view to determining the extent to which carbonized lignite might find a market in that general region. Dr. Zimmerman will make a close study of the fuel supplies available in the northwest, the characteristics of these fuels, and the prices obtained therefor.

The detailing of Dr. Zimmerman to this work marks a further advance in the investigation regarding the possibilities of increased utilization of the northwestern lignites for which the sum of $100,000 was appropriated by the 65th Congress. Recently W. W. Odell, fuel engineer of the Bureau of Mines, was sent to Montreal and Ottawa for the purpose of effecting an exchange of information with the Canadian Government relative to the technical problems involved in the carbonization of lignite. The Dominion Government has for some years been working upon the problem of the utilization of the vast stores of lignite in the western provinces and has spent several hundred thousand dollars in these investigations. The visit of Mr. Odell resulted in the obtaining of much valuable information. The Bureau of Mines is now assured that the lignites of the northwestern states can be converted into a high-grade smokeless fuel, the process yielding quantities of gas, ammonia, oils and tars as valuable byproducts. With the practicability of the carbonization process assured, it remains only to consider the economic side of the situation, and to determine whether the carbonized lignite can compete with the high-grade coals of the central Mississippi and Ohio valleys, which are now being shipped by long freight hauls into the northwest.

Lester Gray French, for 13 yr. editor and assistant secretary of The American Society of Mechanical Engineers, and manager of the journal "Mechanical Engineering," died on April 18 at the French Hospital in the city of New York from septic poisoning following an operation.

Mr. French was born in Keene, N. H., in April, 1869. He received his technical education at the Massachusetts Institute of Technology, from which he was graduated in 1891 with the degree of S. B. He served the year 1891-92 with the Cranston Printing Press Company as draftsman, and then became connected with the International Correspondence Schools, Scranton, Pa., as instructor in mechanical engineering. Leaving this institution in 1895, he went to Providence, R. I., where he entered the employment of the Builders Iron Foundry as assistant to the superintendent. In 1897 he became editor in chief of "Machinery," continuing in this position until 1906, when he resigned to take up the publication of technical books, among them being one of the earliest treatises on the steam turbine, of which he was the author. In 1908 he was made editor of the publications of The American Society of Mechanical Engineers, which organization he faithfully and ably served to the date of his death. With a rare combination of enterprise, vision and dependability, Mr. French developed the publications of The American Society of Mechanical Engineers to a very high standard.

Mr. French was a member of The American Society of Mechanical Engineers since 1899.

N. K. Althause and E. V. Curran have been added to the New York sales force of the Homestead Valve Manufacturing Co., at 242 Lafayette St., New York City.

The New York branch of the Fulton Co., of Knoxville, Tenn., has recently moved from 1476 Broadway to larger and more convenient quarters in the Hudson Terminal Building, 30 Church St., New York City. New and larger quarters have been secured for the Chicago branch in the recently completed Wrigley Building on Michigan Ave., moving from their former location at 175 W. Jackson Blvd.

Pratt & Cady Co. and the Reading Valve & Fittings Co. moved their Chicago offices to 208 So. La Salle St. on May 1 and stocks of their products are carried at their new warehouse, 519 W. Roosevelt Road.

The Botfield Specialties Manufacturing Co. of Philadelphia has recently changed its name and is now trading under the title of Botfield Refractories Co. The personnel of the organization remains the same.

Victor T. Goggin, recently New England sales manager of Fred T. Ley & Co., Inc., of Springfield, has severed his connection with that concern to associate himself as contracting engineer with Dwight P. Robinson & Co., Inc., of New York.

The Hooven, Owens, Rentschler Co. announces that H. F. Kircher & Co., Peoria, Ill.; E. J. MacMillan, 1005 Bates St., Grand Rapids, Mich., and Ross L. Fryer, Albee Building, Washington, D. C., have been appointed representatives in their respective districts.

C. F. Herington, who has been connected for the past 5 yr. with the Bonnot Co. as mechanical engineer and district sales manager in Chicago, resigned May 1, to accept a position as vice-president of the Holbeck Engineering Co., Cleveland, Ohio.

Plans are being prepared for a new one-story electric power plant at the Lewisburg Seminary for Girls, Lewisburg, W. Va. Dr. John I. Anderson is president. Stanhope S. Johnson, People's Bank Building, Lynchburg, Va., is architect.

U. S. Civil Service Commission announces examinations for assistant engineer, $1800 to $2340 a year, and junior engineer, $1440 to $1740 a year, to fill vacancies in the Water Resources Branch of the Geological Survey, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Applications will be rated as received until July 1, 1921. The work will consist of field investigations and the writing and review of the resulting reports. The field of investigation may be in any part of the United States. Graduation from an engineering course of a college or university of recognized standing is a pre-requisite for consideration for these positions, except that for the position of junior engineer applications will be accepted from senior students in such a course conditioned upon their submitting proof of actual graduation within 3 mo. from the date of making oath to the application. Applicants for the position of assistant engineer must have reached their twenty-fifth but not their seventieth birthday on the date of making oath to the application, and applicants for the position of junior engineer must have reached their twentieth but not their thirty-fifth birthday on such date. The minimum age limits do not apply to persons entitled to preference because of military or naval service, and such persons will be admitted to the junior engineer examination if they have not reached their seventieth birthday. Apply for Form 1321, stating examination title.

Trade News

In National Pipe for Refrigerating Systems, a bulletin of the National Tube Co., which has recently come into our hands, we find a great deal of information that should be particularly interesting to the refrigerating engineer.

This book first discusses in a general way the various processes of refrigeration; the compression system, direct expansion and brine systems; and the absorption system. The description does not include all the ramifications found in the modern plant but simply gives in an easily understood manner the general process.

A table of the properties of pipe which includes moment of inertia, section modulus and radius of gyration is given. Pipe sizes from ⅜ to 10 in. in diameter with wall thicknesses from 0.065 to 1 in., a total of about 450 sizes, are included.

Tables giving the properties of brine solutions and saturated ammonia, the refrigerating effect of a cubic foot of ammonia gas at different conditions of suction and discharge pressures, and the displacement and horsepower per ton of refrigeration are worthy of note.

Ten Years' Progress in Water Works Pumps is the title of a manual just published by the De Laval Steam Turbine Co. The first half of the book is devoted to a discussion of the economy of different types of pumping units and to a description of notable installations of turbine-driven centrifugal pumps in municipal pumping plants. The second part, taking up the testing of steam turbines and centrifugal pumps and the measurement of head and discharge, should be of interest to engineers generally, regardless of whether they are connected with water works matters or not. The data presented on the measurement of steam and water by means of Venturi tubes, Pitot tubes, orifices and weirs, is based on an exhaustive search through the literature on the subject in English, German and French. The precautions which must be observed and the degree of accuracy obtainable are indicated, and will be useful to anyone having occasion to make measurements of water flow.

That it may be possible to substitute the cheaper grades of Indiana and Illinois bituminous coal for coke in the generation of water gas, thus reducing the cost of operation of many water-gas plants in the central Mississippi Valley that have been experiencing financial difficulties, is indicated in Technical Paper 246, "Water-gas apparatus and the use of Central District coal as generator fuel," by William W. Odell, fuel engineer, just issued by the United States Bureau of Mines.

A new departure in combustion control devices is described in an illustrated bulletin recently issued by the Mono Corporation of America, 25 West Broadway, New York City. The Duplex Mono, as it is called, is unique in that it automatically analyzes and records the combined percentages of three combustible gases (CO, CH_4 and H_2) during all such times as any or all of these appear in the flue, while it also produces a continuous accurate record of the percentage of CO_2. Both records are on one chart, which is of a new type, clear and easy to read. The plant executive is given a permanent record which gives him the data necessary to compute the degree of efficiency attained in firing, to select his fuel intelligently, make alterations or repairs, and supervise the efforts of the firemen.

The latest bulletin illustrating in general the products manufactured and erected by the Lancaster Iron Works, Inc., Lancaster, Pa., was recently received.

Ice and Refrigerating Machinery Catalog No. 3 has just been received from F. W. Niebling & Co., Cincinnati, O.

A new catalog just published by the M. H. Detrick Co., Chicago, shows by description and illustrations the adaptation of Detrick arches to many different kinds of stokers and boilers.

Operation and installation of the Files hand stoker are discussed in an illustrated booklet, which also gives boiler test reports from various companies. The maker is the Files Engineering Co., Inc., Providence, R. I.

Thwing Instrument Co., Philadelphia, lately issued Bulletin No. 10, treating of the company's Type A thermoelectric pyrometers, both indicating and recording, particularly adapted for power plant work.

A circular regarding Dearboline, a liquid cleaner, for use on machinery and other metal products, has just been issued by Dearborn Chemical Co., 332 S. Michigan Ave., Chicago.

Ten Points of Jones Superiority is the title of a new booklet describing the technical advantages which adapt the Jones "A-C" stoker to the many phases of stoker firing existing in plants in general. The maker is The Under-Feed Stoker Co. of America, Detroit.

The Burning Question is a new book issued by the Green Manufacturing Co., of East Chicago, Ind., dealing with the question of proper combustion. The articles contained therein are written by authorities on combustion and furnace construction. Another book just issued by the same company explains and describes its cast-iron and structural steel hopper.

Superheaters for Stationary Power Plants, Bulletin T-7, pertaining to the advantages of superheated steam and discussing a technical subject in a non-technical manner, has recently been issued by The Superheater Co., 30 Church St., New York.

Copies of this bulletin will be sent on request by addressing the company at its general offices or at any of its branch offices.

Bulletin No. 1-A, Edition No. 1, just issued by the Atlas Valve Co., Newark, N. J., is the first bulletin published by this company describing Ideal pump governors since acquiring the manufacturing and selling rights of these devices. The bulletin shows photographs of finished pump governors, cross-sectional drawings with all parts numbered, installation and operation are fully explained, and it gives dimensions. It includes descriptions of the pump governor for all kinds of drives and types of pump and special types for various services.